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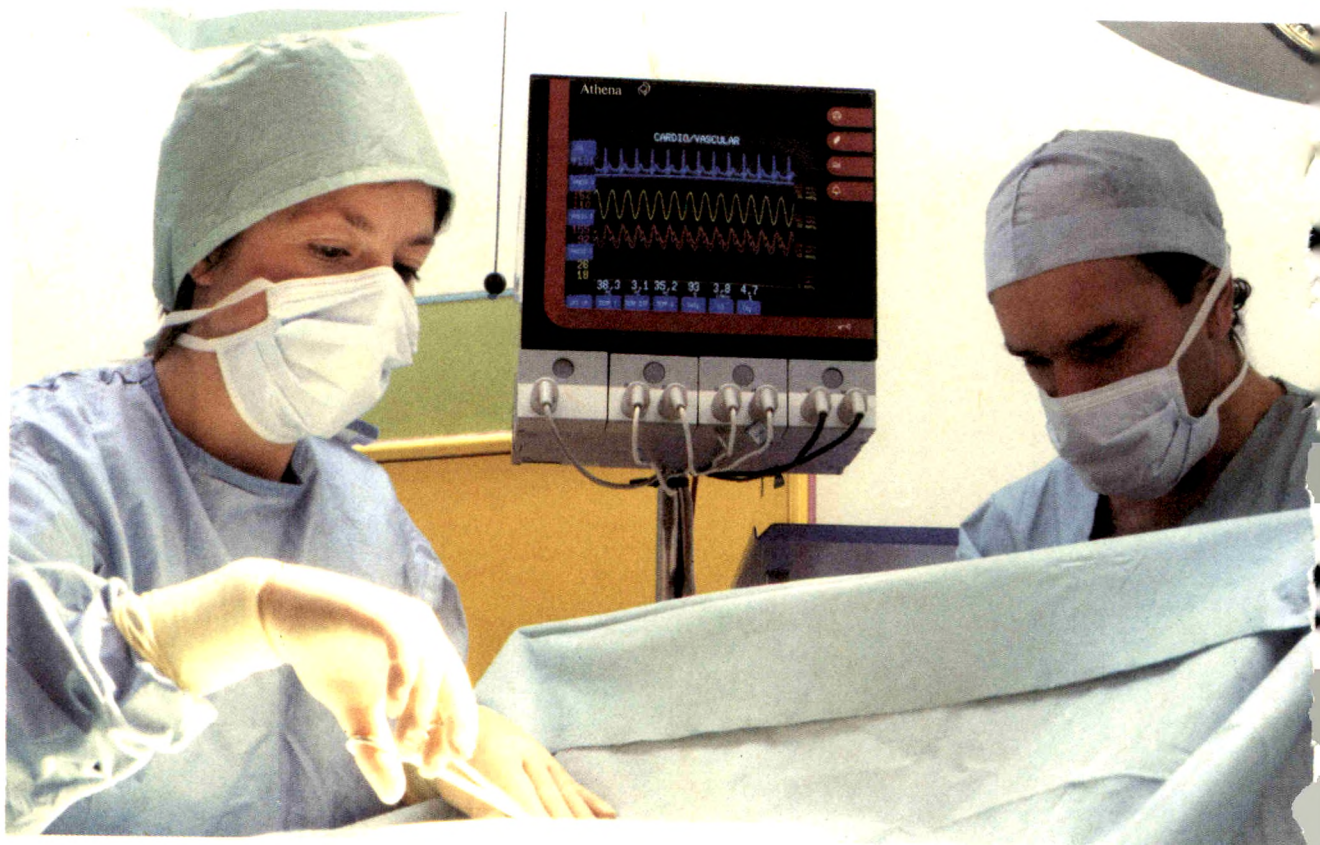
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The work must have been carried out in Canada and completed in the preceding 18 months.

The Chairmen of Canadian University Departments of Anaesthesia (or their deputies) will act as judges. Three prizes (\$500, \$300, \$200) will be awarded to the best of the papers presented at the meeting. The papers to be presented will be selected by the Scientific Programme Committee from abstracts received by January 6, 1989. Abstracts of papers to be presented will be published in the Annual Meeting Supplement of the Canadian Journal of Anaesthesia.

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Editorial

Anaesthetists, lawyers and the public

Anaesthesia is devoted to clinical matters, to change, and to improvements in practice so that our service to patients benefits. The writer does not much relish the concentration of gloom and doom which he endures at the moment since this gives him a somewhat jaundiced view of clinical practice. Nevertheless, the New Year is a good time to review both good and bad, so 1989 will see the introduction of a new regular feature of medicolegal aspects of anaesthesia, which is the result of an idea of Dr R. Greenbaum and is in harmony with the journal's strategy. The aim of the articles (the first appears on p. 64) is to inform anaesthetists more promptly than might otherwise be the case. Diana Brahm is to write about events in all levels of courts in the United Kingdom. She is a barrister and her opinions are her own.

It is time that all doctors, including anaesthetists, faced up to these realities and it is hoped that, by means of these articles, anaesthetists in particular will take note. This is an experiment and I welcome readers' comments, although they need not necessarily be for publication.

It is a relatively rare event for anaesthetists to receive a good press. We are frequently reproached for events which are not always of our making and the praiseworthy efforts of most anaesthetists are ignored. More often than not this criticism, particularly in the press, is derived from judgements in the courts of law. Thus it may be useful for our readers to be aware of the facts as they appear to lawyers without the embellishment of journalists or the delay caused by medical protection mechanisms. Fear of criticism leads, we are told, to defensive medicine which is widely regarded as bad medicine; much of the practice of anaesthesia is, however, defensive because we are on our guard against the unexpected, and this stigma should not apply to us. Negligence is one matter: it has to be proved in court on the balance of probabilities and damage has to be proved to be a consequence of that negligence. There is no medicolegal problem until harm is demonstrated and a claim for negligence laid. Leaving an unconscious patient is another matter; it too is very likely to be proved negligent if harm arises in particular circumstances; even if not negligent, some might consider it to be a dereliction of duty. We have a duty of care and if breach of that duty results in injury to a patient then there is a risk of a claim for medical negligence. The mere fact that a particular patient did not suffer does not absolve the anaesthetist since there is still the matter of duty. Similarly, reading journals, books or newspapers or doing cross-words during supervision of an anaesthetic is not necessarily negligent, but perjorative comments are made (see p. 70) and do apply. The image of anaesthesia-from-the-coffee-room may seem attractive to some individual doctors but onlookers, such as surgeons and nurses, may

have different perceptions: and these people are our colleagues. Those who are not our colleagues certainly do not condone this behaviour and are indignant at the very least.

There is another matter, which needs our prompt attention. Habitual absence from a National Health Service operating list, by an anaesthetist or surgeon, for work in the independent sector or for other professional work not approved by the employer, is not negligent but could be considered to be fraud. This is believed to be relatively uncommon amongst anaesthetists but when it does occur it harms us all by association.

These examples of questionable behaviour enhance the poor public perception with which we have to live. It is unfortunately true that the much more frequent occurrence of impeccable behaviour on the part of anaesthetists is not only insufficient to redress the balance but also goes totally unrecognised.

The pursuit of quality and assurance of quality in medicine is now overt although in reality it has always been part of the practice of medicine. However, when that quality is not achieved, it sometimes happens that the differentiation between responsibility and blame is blurred. This should not be; in other fields those who are proud to accept responsibility, and all that goes with it, are expected to make recompense. Public servants, in the old days, would admit to failure and resign from office in such circumstances. Nowadays it is common in medical circles for blame to be ascribed or even accepted; and yet there is no punishment, only an attempt at recompense for the injured which sometimes appears also to be mean.

Furthermore, even in serious cases, in which negligence is admitted and for which no defence can be offered, the settlement is made out of court and the defendant remains anonymous. The much-vaunted investigative procedure after an accident which involves pilots of aircraft suffers the same disadvantage. Secrecy and the risk of double jeopardy limit the effectiveness even of this scheme which is otherwise superficially attractive to us. The contrast between ourselves and another learned profession is even more remarkable. The Law Society's Gazette regularly publishes a list of names of lawyers who have offended their professional code. Their offences are also summarised. The General Medical Council does similarly but does not deal with clinical matters. Is it time for more openness in medicine?—then, at least, our critics could no longer accuse us of protective self-interest.

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J.N. LUNN
Editor

The influence of patient characteristics on the requirements for postoperative analgesia

A reassessment using patient-controlled analgesia

J. W. BURNS, N. B. A. HODSMAN, T. T. C. McLINTOCK, G. W. A. GILLIES,
G. N. C. KENNY AND C. S. McARDLE

Summary

The requirements for analgesia after upper abdominal surgery were evaluated in 100 patients who received morphine by way of a patient-controlled analgesia system. Hourly and cumulative 24-hour requirements were analysed for possible correlations with patient characteristics and for the patterns of consumption throughout the 24-hour study period. The level of pain relief was assessed by linear analogue pain scores at 4-6 hours and 24 hours. Male patients ($n = 46$) required significantly more morphine than female patients ($n = 54$) to achieve similar levels of pain relief ($p < 0.05$). There was an inverse correlation between age and morphine consumption in both males and females ($r = -0.684$, $p < 0.00005$ and $r = -0.502$, $p < 0.00005$ respectively). No correlation was found between morphine consumption and patient weight. The pattern of hourly morphine consumption appeared to follow a diurnal rhythm, with peak times of demand at 0900 and 2000 hours. The variations in requirements for analgesia among patients and with time of day should be taken into account when a regimen for postoperative analgesia is prescribed.

Key words

Analgesia; postoperative, patient-controlled analgesia.

Effective postoperative analgesia is of paramount importance, particularly after major abdominal surgery. Several studies have reported a wide range of individual requirements for, and responses to, analgesic drugs.¹⁻³ However most patients still receive intramuscular opioids,⁴ prescribed at fixed time intervals, for pain relief in the early postoperative period. The bolus dose is determined usually by patient variables such as age, gender and weight, which are considered to influence the pharmacokinetic profile of analgesic drugs, although previous studies have shown no correlation between weight, height or body surface area and pain relief after a single dose of morphine or pentazocine. A significant inverse correlation between age and pain relief has been demonstrated.^{5,6}

Patient-controlled analgesia (PCA) is a relatively new concept in the management of postoperative pain.⁷ It provides a unique opportunity to examine the requirements for analgesia and to reassess the factors which are thought to influence them. We have studied the morphine requirements of 100 patients who received morphine delivered by a PCA system as the sole method of analgesia in the first

24 hours after upper abdominal surgery, and analysed these requirements with regard to age, weight, gender and time of day.

Methods

One hundred patients aged 18-75 years, who had undergone upper abdominal surgery were studied. Patients with cardiac, hepatic, or renal dysfunction were excluded, as were those patients who received regular analgesic drugs pre-operatively. All patients had given informed consent for the study.

The system comprised an Imed 929 computer-controllable infusion pump connected to an Apple IIe micro-computer.⁸ The PCA system was connected to the patient's intravenous infusion by way of a nonreturn valve, and was programmed to deliver an incremental dose of morphine 0.02 mg/kg, with a lock-out interval of 2 minutes. Maximum dosage was 0.4 mg/kg in one hour. Start time and the time of each bolus dose were recorded and stored on disk. Pain relief was assessed using a horizontal 100-mm visual

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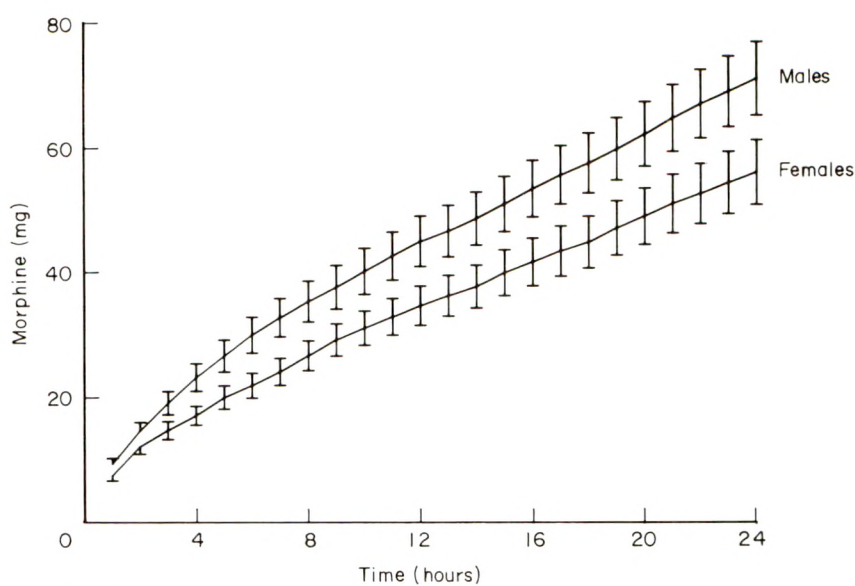


Fig. 1. Mean cumulative morphine consumption for males and females. Bars represent SEM. Significant difference between groups $p < 0.05$.

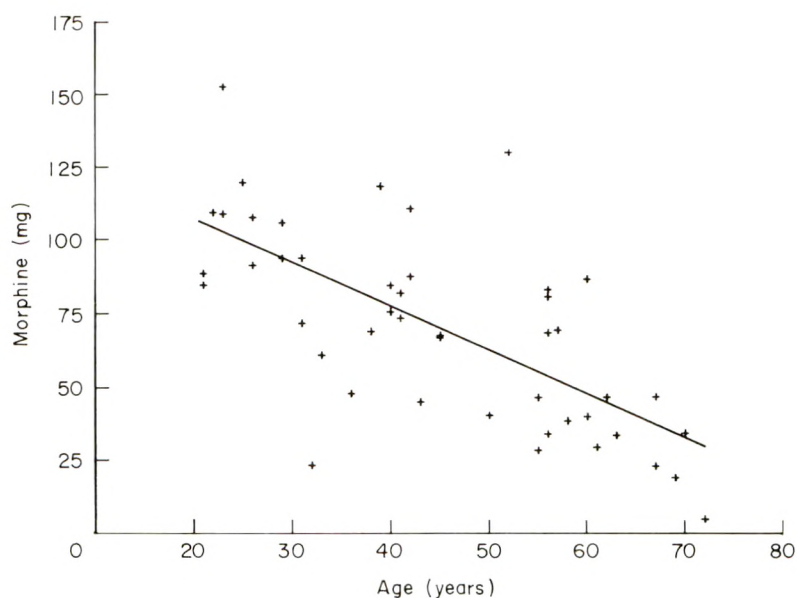


Fig. 2. 24-hour morphine consumption related to age for males. $n = 46$; $r = -0.684$; $p < 0.00005$.

analogue; scores were recorded at 4–6 hours and again on completion of the study period at 24 hours.

The cumulative 24-hour morphine requirements were then analysed with regard to a variety of patient characteristics that included age, weight and gender. Differences between groups were analysed using Student's t -test for parametric data and two-tailed Mann–Whitney U tests for nonparametric data. The relationships between morphine requirements and patient characteristics were determined by linear regression analysis.

Results

The mean age and weight, and the gender of the 100 patients included in the study are shown in Table 1. There was a significantly greater 24-hour morphine consumption by males than females (Fig. 1, Table 2).

Table 1. Age and weight of male and female patients. Data are expressed as mean (SD).

	Males ($n = 46$)	Females ($n = 54$)
Age, years	44.9 (15.3)	47.7 (14.5)
Weight, kg	67.7 (11.1)	63.3 (12.4)

Morphine consumption over 24 hours was analysed separately for males and females and compared with age (Figs 2 and 3). There was a significant decrease in morphine consumption with increasing age in both groups. However, there was no correlation between age and the level of pain relief achieved at either 4–6 or at 24 hours (Table 2). Weight and 24-hour morphine consumption were analysed separately for males and females. There was no correlation between weight and morphine consumption in either group.

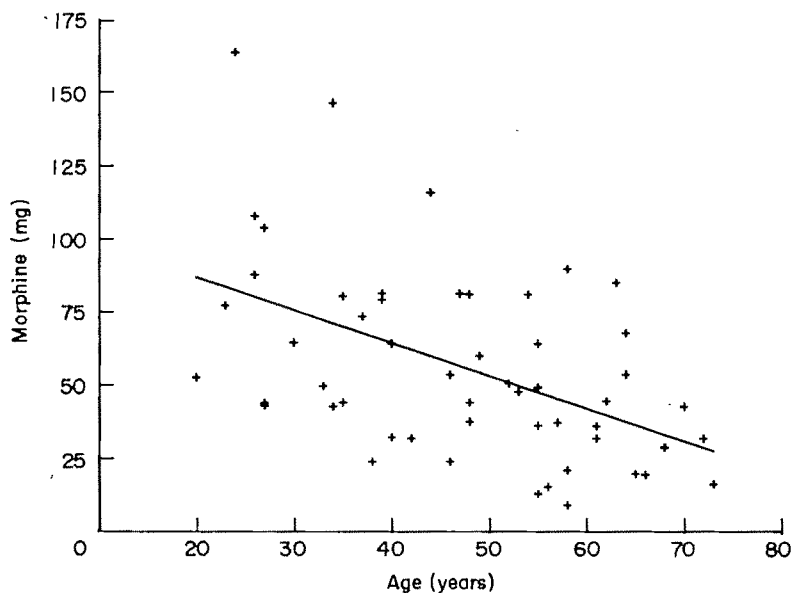


Fig. 3. 24-hour morphine consumption related to age for females. $n = 54$; $r = -0.502$; $p < 0.00005$.

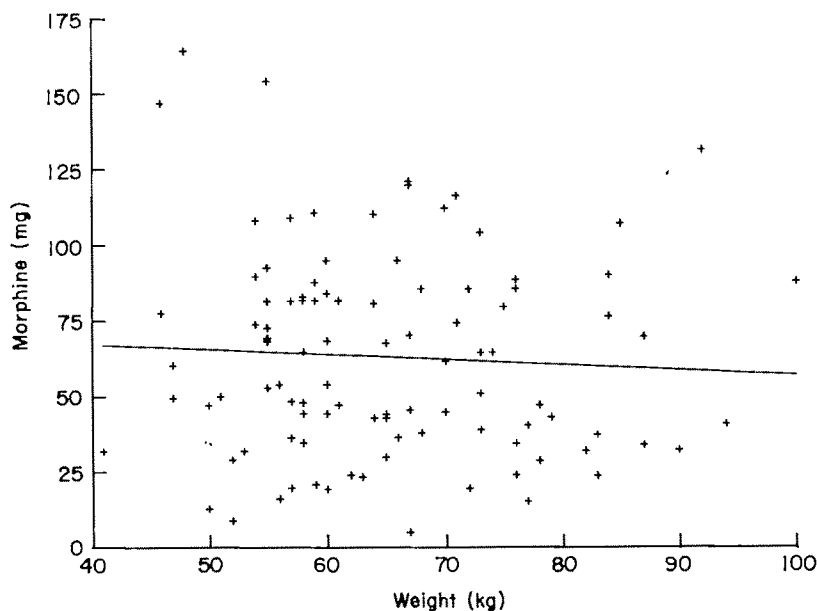


Fig. 4. 24-hour morphine consumption related to weight. $n = 100$; not significant.

Table 2. The 24-hour morphine consumption and linear analogue pain scores for males and females. Data are expressed as median (range).

	Males	Females
24-hour morphine consumption, mg	71.4 (5.2–154.0)	48.8 (9.0–164.0)*
Linear analogue pain scores, mm		
4–6 hours	45 (0–100) $n = 35$	40 (2–84) $n = 41$
24 hours	24.5 (3–74) $n = 38$	26.5 (0–72) $n = 46$

* $p < 0.05$.

The combined results for all 100 patients are shown in Figure 4.

The pattern of morphine consumption was analysed for all 100 patients. The data from the first 6 hours were dis-

carded to exclude the loading phase, during which patients achieved optimum blood concentrations of morphine, and the hourly morphine consumption over the remaining 18 hours were then plotted against time over 24 hours (Fig. 5). Two distinct peaks in consumption can be seen at 0900 and 2000 hours.

Twenty-six patients started the study between 1000 and 1100 hours. The pattern of their hourly morphine consumption, excluding the loading phase, showed a similar diurnal variation, with increased consumption at equivalent times of day (Fig. 6).

Discussion

Previous studies have relied on information derived from the results of single doses of analgesic, and involved

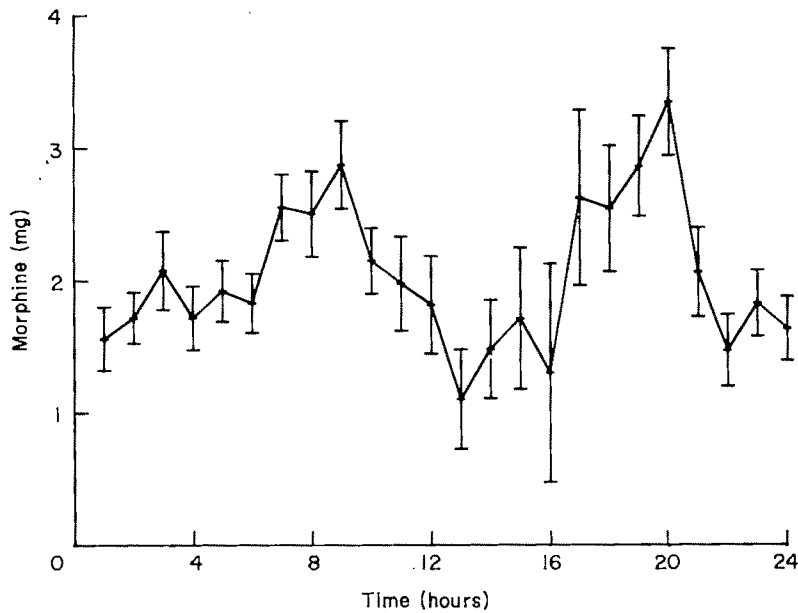


Fig. 5. Hourly morphine consumption during the last 18 hours of the study period ($n = 100$).

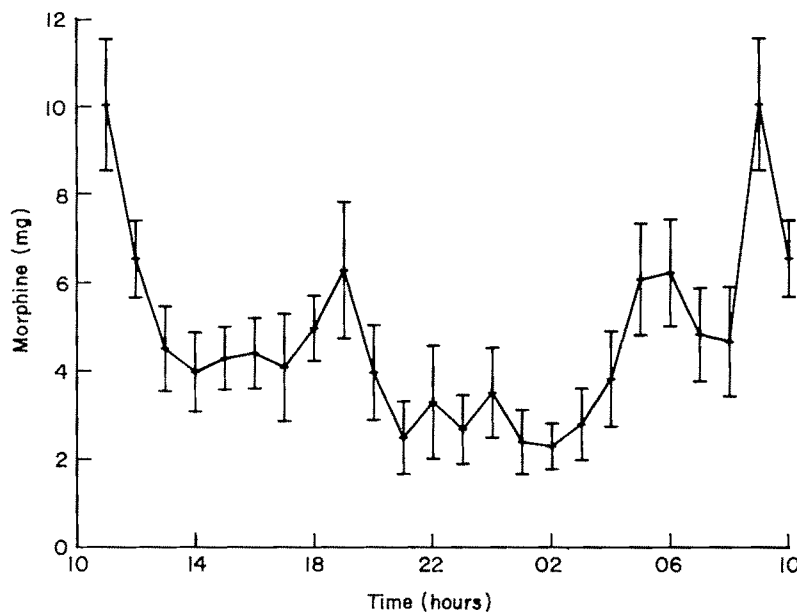


Fig. 6. Hourly morphine consumption of patients who started the study between 1000 and 1100 hours ($n = 26$).

assessments by several different nurse assessors in more than one centre.^{5,6} Patient-controlled analgesia allows each patient to titrate the amount of morphine required to relieve pain, and is ideally suited to the study of analgesic requirements over a period of time without observer bias.

The results of this study suggest that morphine requirements decrease with increasing age. The explanation for the effects of ageing on analgesia is primarily pharmacokinetic. Previous studies have demonstrated a decreased volume of distribution for morphine with increasing age, and the resultant increase in the initial serum concentrations of morphine after intravenous injection correlate directly with age.⁹ The result is a decreased clearance of morphine from plasma, and an increase in clinical effect in the elderly.^{9,10}

Our results did not demonstrate any correlation between patient weight and morphine requirements. This supports the findings of other studies which have shown no correlation between analgesic requirements and weight, height, or body surface area.⁵ These patient characteristics may influence the blood concentration of morphine, but circulating blood levels cannot be related to analgesic effects.¹¹ The poor lipid solubility of morphine creates a delay in the equilibration of a given plasma concentration and opioid receptor site concentration. In addition, there is a wide individual variation in the perception of pain and efficacy of analgesia. This may be related to personality traits,¹² and/or variations in the percentage occupancy of opioid receptor sites by beta-endorphins.¹³

Previous studies that assessed variations in the require-

ments for analgesia between males and females have produced conflicting results. Two small studies using PCA with morphine and pethidine in 20 and 10 patients respectively, found no significant differences between the analgesic requirements of males and females.^{14,15} However, a study of 16 females and 25 males suggested an increased tendency amongst the females to rate their pain as more intense.¹⁶ The wide individual variation in requirements for analgesia requires large numbers to be studied in order to ensure reliable results.

The reasons for the increased requirements in males in this study is not clear. Any reluctance to use the PCA apparatus or greater acceptance of postoperative pain amongst female patients should have resulted in higher pain scores as an indication of poor pain relief. Rigg *et al.*¹⁷ reported similar maximum concentrations and times to maximum concentration after intramuscular injection of morphine in males and females, which would indicate similar volumes of distribution. They also reported a shorter elimination half-life for morphine in females, but this should have increased their requirements. Personality factors are recognised to influence requirements for postoperative analgesia,¹² and it may be that there was a higher incidence in males in our study of those aspects of personality which tend to increase requirements.

The pattern of morphine consumption in our study showed considerable variation in hourly requirements at some times of day. The diurnal variation of plasma cortisol and ACTH is well known. The pattern of plasma beta-endorphin concentration parallels this circadian rhythm with trough levels that occur at 2200–0300 hours, and peak levels at 0400–1000 hours.⁸ A previous study showed that plasma pethidine concentrations (which correlate well with pain relief)¹¹ were related inversely to endorphin concentrations in cerebrospinal fluid.¹⁰ Thus, morphine requirements ought to be highest at about midnight when endorphin levels are at their lowest, but our results do not support this hypothesis.

An alternative explanation for these findings arises from a previous study on the level of noise in surgical wards, which is relatively constant, except between 2200 and 0630 hours,²⁰ and this would appear to match the pattern of analgesic requirements more closely. The diurnal variation in morphine consumption may therefore be related to ward activity. Increased requirements around 0900 hours could be associated with the morning ward round and routine nursing duties, and the early evening demands by increased ward activity around the visiting time.

In conclusion, the required dose of postoperative analgesia decreases with increasing age, and males require higher or more frequent doses than females. There is a poor correlation between analgesic requirements and weight, and careful assessment of the individual in the postoperative recovery area with titration of intravenous bolus doses to response is perhaps the best guide to determine the appropriate dose regimen in the subsequent postoperative period. The apparent diurnal variation in morphine requirements should be taken into account when postoperative analgesia is prescribed if PCA is not available. This variation in analgesic requirements may render single dose studies less appropriate in assessment of analgesic potency unless time of administration can be controlled strictly.

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Variables of patient-controlled analgesia

1. bolus size

H. OWEN, J. L. PLUMMER, I. ARMSTRONG, L. E. MATHER AND M. J. COUSINS

Summary

The efficacy of a range of demand doses of morphine for patient-controlled analgesia was studied. Patients who self-administered the smallest dose (0.5 mg) were frequently unable to achieve good pain control; patients who received the largest dose (2 mg) had a high incidence of ventilatory depression. A dose of 1 mg was the best increment under the conditions of this study but the relationship between increment and lockout interval requires consideration.

Key words

Pain; postoperative.

Analgesia; on-demand.

Patient-controlled intravenous opioid analgesia (PCA) has been used for over 20 years.¹ Early primitive apparatus has been replaced with sophisticated bedside drug delivery systems which can be programmed simply by the attending medical or nursing staff.² The quantity of analgesic available to the patient is limited primarily by the prescribed PCA variables; demand dose size (increment) and lockout interval (minimum time between doses). It is assumed that patients will demand repeated doses of analgesic agent until pain has been relieved. However, the demand dose size and lockout interval appear to influence the patient's perception of treatment effectiveness.

Too small a demand dose may result in a large proportion of patients failing to achieve adequate analgesia. Lehmann *et al.*^{3,4} studied the agent tramadol in PCA. Thirty-eight percent of patients had inadequate pain relief when the demand dose was 9.6 mg, compared with only 5% of patients in a later study using a demand dose of 18.5 mg. Mean frequencies of hourly demands were similar in both studies, but almost twice as much analgesic agent was self-administered in the latter study. This unwillingness of some patients to increase the rate of demand to achieve pain control, in the face of a small prescribed demand dose, has been noted previously.⁵ Of course, too large a demand dose may produce adverse effects which result also in failure of the technique.

The most appropriate size of demand dose when morphine is used is the source of considerable debate. Originally,

as little as 0.1 mg was used per demand.¹ More recently, White⁶ suggested that 1 mg is appropriate, but Rosen⁷ described 2 mg as modest and incremental doses in the range of 2-4 mg as satisfactory. Bennett⁸ recommended an initial incremental dose of 1 mg although this dose was based on mean requirements of patients over several days after laparotomy, during which time pain severity progressively diminished. Tamsen *et al.*⁹ recorded the usual demand bolus dose as 1-3 mg and Lehmann *et al.*¹⁰ used 1.92 mg in their studies.

The size of demand dose may have an important bearing on success of PCA. Consequently a prospective randomised study was undertaken to examine the effects of different demand dose sizes of morphine when used in PCA after upper abdominal surgery.

Methods

Results from a previous study¹¹ suggested that 60 patients should be included in the study to enable detection of small but important differences in total morphine consumption. However, it was also felt possible that one treatment could be grossly inferior to the others; therefore a group sequential design¹² was chosen in which the maximum number of patients was 60 but interim analyses would be conducted after enrolment of 21 and 39 patients. The overall Type I error is kept at approximately 0.05 by keeping the Type I error rate at 0.02 for each analysis. The randomisation was

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carried out in blocks, such that treatment groups would be of equal size for each analysis in order to obtain maximum power for each analysis.

The study was approved by the Clinical Investigation Committee at Flinders Medical Centre. All patients gave their informed consent and were tutored pre-operatively on the use of PCA. A standardised anaesthetic technique was used in all cases; morphine was the only analgesic agent used for intra-operative analgesia and for premedication. Morphine was administered after operation by PCA from a Lifecare PCA-Infuser by way of an intravenous fluid infusion line that incorporated a one-way valve. Patients were allocated randomly to receive a demand dose of 0.5 mg, 1 mg or 2 mg morphine tartrate; the lockout interval was 5 minutes for all demand doses. PCA was initiated in the recovery area after the patient had been titrated to 'no pain' using 2.5 mg increments of morphine administered intravenously. All subsequent assessments were made by ward nursing staff who had been tutored on the use of the pain scale and were unaware of which bolus dose had been chosen for any patient.

Residual pair was recorded at the end of each hour for 24 hours on a four-point ordered-categories scale (0 = no pain; 1 = mild pain; 2 = moderate pain; 3 = severe pain). The total amount of morphine self-administered, the number of valid demands made and the incidence of nausea and vomiting were also recorded. The patient was withdrawn from the study if there was inadequate analgesia or a pain score of 2 or more on consecutive assessments, or if the patient developed a reduction in ventilatory rate to less than 10 breaths/minute or complained of severe opioid-related side effects. Otherwise, PCA was continued for 24 hours.

Fisher's exact test was used in the comparison of numbers of patients withdrawn due to inadequate pain relief or excessive opioid-related side effects. Student's *t*-test was used to compare age, weight and hourly rate of self-administration of morphine.

Results

The groups were similar in respect of age and weight (Table 1), sex ratio and type of surgery. The study was terminated after the first interim analysis (21 patients enrolled) because of the number of patients withdrawn with inadequate pain relief or opioid-induced side effects. The frequencies of these withdrawals from each group are shown in Table 2. Significantly more (6 of 7) patients in the 0.5 mg dose group were withdrawn as a result of inadequate pain relief than in the other dose groups (2 of 14) (*p* < 0.01). All patients had been pain-free at the start of PCA; the amounts of morphine administered intra-operatively and in the recovery area are shown in Table 3. Five patients in the 2 mg demand dose group were withdrawn because of severe opioid-induced side effects compared to none in the other dose groups (*p* < 0.01). Four of these five patients had developed ventilatory depression; the other patient had severe nausea and vomiting, which was not controlled by large doses of metoclopramide or prochlorperazine, immediately after each demand. There were no differences in the incidences of nausea, vomiting or administration of antiemetics among the three treatment groups.

The duration that patients remained in the study (i.e. until they were withdrawn or 24 hours), the mean cumula-

Table 1. Demographic and surgical data for each demand dose group. Values expressed as mean (SD) and range.

	Demand dose (mg)		
	0.5 <i>n</i> = 7	1.0 <i>n</i> = 7	2.0 <i>n</i> = 7
Age, years	47.9 (19.9) 20-75	49.0 (15.0) 28-66	46.0 (13.9) 26-69
Weight, kg	58.3 (17.1) 40.5-92.7	65.5 (10.6) 53.4-77.3	63.8 (5.4) 57.0-73.5
Type of surgery			
Cholecystectomy	4	4	4
Highly selective vagotomy	1	0	3
Transduodenal sphincteroplasty	1	1	0
Right hemicolectomy (extended)	1	1	0
Anterior resection	0	1	0

Table 2. Frequency of withdrawals from each demand dose group.

Reason for withdrawal	Size of demand dose		
	0.5 mg	1 mg	2 mg
Inadequate pain relief	6	2	0
Severe opioid-related side effects	0	0	5
Not withdrawn	1	5	2

Table 3. Synopsis of analgesia received and demands made by patients according to response. Values expressed as mean (SD) and range.

	Inadequate pain relief	Serious opioid-related side effects	Not withdrawn
Number of patients	8	5	8
Intra-operative morphine, mg	8.6 (4.5) 0-15	11.0 (5.7) 2-20	11.1 (4.9) 5-20
Dose of morphine in recovery ward, mg	10.0 (0) —	7.9 (3.9) 0-10	9.6 (0.9) 7.5-10
Duration in study, hours	11.0 (8.5) 2-21	14.8 (8.4) 7-23	24.0 (0) —
Total self-administered dose, mg	14.9 (9.1) 4-13	59.6 (36.4) 16-106	27.9 (20.5) 10-59
Hourly dose, mg	2.0 (1.3) 0.7-4.5	3.5 (0.9) 2.0-4.3	1.1 (0.9) 0.4-2.4
Demands per hour	4.0 (2.7) 1.4-9.0	1.8-(0.5) 1.0-2.3	1.1 (0.7) 0.2-2.5

tive dose of morphine during this time, mean dosage rate, and demand rate are shown in Table 3. Up to 12 demands per hour were available for all patients but eight patients were withdrawn because of inadequate pain control. This suggests that they were unable or unwilling to demand frequently enough to achieve pain control. Four patients (all of whom received 2 mg per demand) self-administered substantially more analgesic than the others and developed ventilatory depression.

Discussion

We found that the success of PCA (efficacy and absence of side effects) does depend on the size of the demand dose. This is in sharp contrast to the widely held assumption that patients will always self-administer an analgesic agent which just maintains an analgesic drug concentration in blood.^{9,13} Our conclusion is consistent with the results of

studies using two different demand doses of tramadol.^{3,4} In addition, a study by Keeri-Szanto,⁵ in which the size of demand dose of hydromorphone was changed over a four-fold range, found that a significant proportion of patients (at least seven out of 34) apparently demanded to an endpoint other than return of pain.

Some studies have shown that PCA may be no more effective than traditional intermittent intramuscular administration.¹⁴⁻¹⁶ Even with PCA, a cycle of pain/discomfort followed by analgesic administration and relief is set up, although it may result in only mild or moderate pain for at least part of the time. This phenomenon would be exaggerated by inappropriate choice of the demand dose.^{4,16,17} Patients usually prefer PCA despite similar pain relief and similar opioid consumption.¹⁸ This may be because of the perceived advantages of being in control of pain relief rather than actual superiority of the technique. However, poorly prescribed PCA (i.e. lockout interval too long or demand dose too small or too large) may prevent some patients from receiving enough analgesic agent, discourage them by lack of appreciable effect after each demand or having to wait, in pain, for the next dose, or lead to unacceptable levels of opioid-related adverse effects.

Eight patients, six of whom received the smallest dose (0.5 mg), complained of poor pain control in the present study. These patients could have made a demand every 5 minutes (i.e. 12 per hour), but made only a mean of 4.0 demands (range 1.4-9) per hour (Table 3). The reason for this is not clear; some patients questioned on this point were either unwilling to make more frequent demands because they expected to perceive analgesia after each dose or were afraid that they might self-administer too much analgesic agent. All the patients withdrawn from the study because of inadequate pain relief at one demand dose size achieved good pain control subsequently with a larger demand dose. There may be a (self-imposed) maximum demand rate which patients are reluctant to exceed, irrespective of the demand dose. It has been proposed previously that time since last dose is important to patients.⁵

It is also unclear why so many patients who received 2 mg per demand, and only patients in this group, self-administered enough opioid analgesic to cause ventilatory depression (using a definition suggested by Rosen⁷ and Bennett *et al.*¹⁹ of less than 10 breaths/minute). It is acknowledged that frequency of ventilation bears no constant relationship to the degree of depression as judged by other standards. However, frequency is reduced in severe drug-induced depression and is the clinical guide most commonly employed. A slow ventilatory rate indicates also a reduced margin of safety and should prompt a review of therapy. The respiratory consequences of PCA are reputedly small in the absence of other risk factors. The slowest recorded respiratory rate in 1333 observations in a survey of 50 post-surgical patients who received PCA was 12 breaths per minute.¹⁹ However, an initial demand dose of morphine of 0.6 mg/sq m was used and adjusted over the next 3 days according to patient response in 0.2 mg/sq m steps. It is possible that a degree of tolerance to the ventilatory depressant effect of morphine would have developed as the demand dose was increased. In contrast, bradypnoea has been described also in patients who self-administered morphine, 0.02 mg/kg/demand with a 2-minute lockout.²⁰ Thus, the safety of the technique may have been overstated unless conditions are controlled carefully. The ideal lock-

out interval is likely to be agent-specific and we suspect that there is a complex relationship between lockout interval and demand dose. There have been attempts to determine a rationale for setting the lockout interval²¹ but review of this subject is hindered by the frequent failure to describe these variables in reports on PCA use. It is possible that a larger dose would be satisfactory if a longer lockout interval is prescribed. Indeed there is a continuum through smaller doses superimposed on a constant-rate infusion to a patient-controlled variable-rate infusion. However, PCA research has concentrated to date on its efficacy in specific situations or on differences between drugs.

The optimal demand dose may be defined as the minimum dose to produce appreciable analgesia consistently without causing either subjective or objective side effects. We believe that the optimal demand dose for morphine is close to 1 mg. This is comparable to the 0.6 mg/sq m reported by Bennett⁸ at the end of PCA therapy and suggests that clinically significant tolerance to the analgesic effects of morphine does not occur in this situation. The relative effectiveness and potency of different opioids for PCA have been compared mostly using a single dose of each. However, such comparisons may have little value, as the size of the demand dose is critical for success. Dose-response relationships for each agent must be ascertained, and future comparisons made at the optimal doses.

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Variables of patient-controlled analgesia 2. concurrent infusion

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Summary

The effectiveness of morphine after surgery by patient-controlled analgesia alone or with a concurrent infusion was studied. The infusion did not reduce the dose of self-administered analgesic and patients treated in this way received twice as much drug as those who used patient-controlled analgesia alone. Pain control was similar in both groups. The practice of patient-controlled analgesia plus infusion requires critical review.

Key words

Pain; postoperative.

Analgesia; on-demand.

The technique of patient-controlled analgesia (PCA) requires that the patient experience pain or discomfort before obtaining relief. If a drug with only brief analgesic action, e.g. fentanyl, is used then analgesia can be achieved rapidly, but a sustained high demand frequency is required to maintain pain relief. Patients who fall asleep may be awoken by pain and require several demands, subject to the lockout interval, to recover pain control. Thus it is believed that the concurrent administration of a continuous infusion (CI) of fentanyl improves the continuity of analgesia significantly.^{1–3} Morphine is the opioid agonist used most frequently for PCA. An infusion that is sufficiently large to abolish demands (i.e. completely suppress pain) increases the risk of ventilatory depression unless the rates of infusion and breathing are monitored continuously. Thus, the aim of continuous infusion of morphine with current PCA devices is to reduce the need for patients to make demands.⁴ A comparison of morphine administered by CI at 20 µg/kg/hour and placebo showed that the analgesic infusion appeared to contribute little to pain control by intermittent intramuscular injection in the first 24 hours after surgery when assessed by nursing staff.⁵ Similarly, a comparison of two PCA devices noted that one machine which delivered an additional 1 mg/hour morphine by mandatory CI did not provide better analgesia than a machine with no CI.⁶ Four out of 30 patients developed significant bradypnoea when 2 mg/hour morphine by CI

was used to supplement PCA.⁷ The present study was undertaken to investigate the contribution of a significant, but presumed safe, CI to the effectiveness of PCA.

Methods

The study was approved by the Clinical Investigation Committee at Flinders Medical Centre. All patients gave their informed consent and were tutored pre-operatively on PCA. A standardised anaesthetic technique was used in all cases; morphine was the only analgesic used for intra-operative pain control and for premedication. Postoperatively morphine tartrate was administered from an On-Demand Analgesia Computer (ODAC) by way of an intravenous fluid infusion line that incorporated a one-way valve. Patients were allocated randomly to receive wholly self-controlled administration (PCA)* or to self-administer morphine in addition to a mandatory infusion of 1.5 mg/hour (PCA plus CI). The demand dose was 1 mg, with a lockout interval of 2 minutes and the maximum self-administered dose was set at 6 mg/hour.

Approximately 2 mg/hour morphine was self-administered by PCA in a previous study on a similar group of

* The ODAC has a minimum infusion rate of 0.01 ml/minute. Thus, the PCA group received an infusion of 0.12 mg/hour morphine in addition to PCA.

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patients.⁸ We would expect this group to demand on average only 0.5 mg/hour if the CI (1.5 mg/hour) in the current study was effective. We determined by an estimate of variability in mean hourly demand rate from the previous study, that nine patients should receive each treatment to provide a power of 80% to detect such a difference at a Type I error rate of 0.05.⁹ The ODAC was connected to the patients in the recovery room after the patient had been titrated to 'no pain' using 2.5-mg increments of intravenous morphine. All subsequent assessments were made by ward nursing staff tutored in the use of the pain scales. Only the first 24 hours of PCA use were studied. Residual pain was recorded at the end of each hour for 24 hours in a four-point ordered-categories scale (0 = no pain; 1 = mild pain; 2 = moderate pain; 3 = severe pain). The area under the pain score-time curve (pain AUC) was calculated for each patient. A pain score between those recorded at adjacent times was allotted for the hours in which the patient was asleep at the time of observation. The total amount of morphine self-administered and infused, the number of valid demands made and the number of times nausea or vomiting required treatment were also recorded. In addition, severity of nausea over the 24-hour period was assessed on a categorical scale (0 = none; 1 = some/moderate; 2 = severe). PCA was discontinued if the patient developed significant reduction in ventilatory rate, i.e. less than 10 breaths/minute.⁴

The Wilcoxon Rank Sum test was used in the comparison of total morphine dose, number of valid demands, pain AUC and number of doses of antiemetic administered in the two groups.

Results

A total of 22 patients were enrolled in the study to obtain the required group sizes, as data from three patients could not be used; one patient returned to theatre because of postoperative haemorrhage (see below), and in two cases the ODAC did not deliver all demands.

Use of PCA was discontinued in two patients, both in the PCA-only group (after 11 and 20 hours), because of unacceptable levels of nausea and vomiting associated with demands. Data from these patients were excluded from statistical analyses that required data for all 24 hours. The maximum nausea score of 2 was assigned to these patients. Groups were similar in respect of age, weight and surgical procedure (Table 1). The number of valid demands and cumulative dosage of morphine are shown in Table 2. Both groups self-administered similar amounts of morphine; however, one group was receiving a mandatory infusion in addition to PCA and thus received over twice as much drug ($p = 0.0003$). Despite this, there was no difference in pain scores (pain AUC) between the groups (Table 2).

There were no great differences in ventilatory rates between the two groups despite the disparate morphine administration. Only one patient developed ventilatory depression (frequency below 10 breaths/minute); this was attributable to a large postoperative haemorrhage, and responded promptly to transfusion. There was no correlation between nausea score and pain AUC. Neither age nor weight correlated with morphine dose. There was no significant difference in the number of antiemetic injections administered to the groups (Table 2), but patients who received a concurrent infusion had less nausea ($p = 0.02$).

Table 1. Demographic data for the two groups. Values expressed as mean (SD) and range.

	PCA only	PCA + infusion
Age, years	38.9 (9.8) 23–51	44.3 (10.7) 31–63
Weight, kg	69.2 (14.2) 53.3–104.2	74.8 (20.7) 48.8–107.2
<i>Operative procedure</i>		
Abdominal hysterectomy	6*	7
Hysterectomy and oophorectomy	1*	1
Oophorectomy	2	0
Division of adhesions and tubal surgery	1	0
Diagnostic laparotomy	0	1

* One patient in each of these groups discontinued PCA use early because of nausea.

Table 2. Summary of postoperative observations. Data are expressed as mean (SD) and range.

	PCA only	PCA + infusion	p*
Valid demands	31.0 (14.6) 14–56 $n = 8$	35.8 (16.3) 15–64 $n = 9$	0.54
Total dose of morphine, mg	33.9 (14.6) 16.9–58.9 $n = 8$	73.8 (16.3) 51–100 $n = 9$	0.0003
Pain AUC	20.6 (6.1)	19.2 (12.2)	0.67
0–24 hours	12.5–31.5 $n = 8$	4.5–38.5 $n = 9$	
Doses of antiemetic	3.5 (2.0) 0–6 $n = 8$	2.1 (1.7) 0–4 $n = 9$	0.14
Nausea score	1.4 (0.7) 0–2 $n = 10$	0.7 (0.7) 0–2 $n = 9$	0.02

* Wilcoxon rank sum test.

Discussion

Results of this study demonstrate that the addition of a constant rate infusion to PCA neither improved the effectiveness of the technique nor reduced the number of demands. One would expect either that the dose of self-administered analgesic agent would be reduced by an equivalent amount to that administered by the mandatory infusion or that this hybrid control system would provide superior analgesia,^{4,10,11} but neither occurred. This confirms the results of a study in which CI of morphine (20 µg/kg/minute) did not reduce the requirement for nurse-administered analgesic compared to patients who received placebo infusion.⁵ Similarly, Vickers *et al.*⁶ noted when they compared two PCA systems that a small concurrent infusion did not reduce opioid analgesic requirements.

Several studies have reported the effectiveness of the combination of constant rate infusion plus PCA, but have not compared it with PCA alone.^{1,12} Other workers have used variable rate infusions which adapt the mandatory infusion rate automatically to reflect the frequency of analgesic self-administration.^{3,12} A short-acting analgesic was used in these studies, and a background infusion was used in an attempt to circumvent the expected need for high demand rates which patients could not sustain^{10,14} and to obviate the need for patients to be awoken frequently by pain after short periods of sleep.¹⁰ The alternative is to use a

longer acting agent which should reduce demand frequency. The rationale for use of the shorter-acting agents e.g. fentanyl or alfentanil, is their rapid onset of action. However, this has not been shown to confer any overall analgesic advantage. Comparison of results from different studies is difficult because the values for the system variables (demand dose size and lockout interval) are seldom reported. Both of these variables have a crucial bearing on the success of the technique.^{13,14} Systematic studies of PCA variables have not been undertaken.

The addition of mandatory infusion to PCA not only fails to improve efficacy but it also reduces the inherent safety of the technique. Many early PCA devices had an inbuilt reaction-time test to obtain analgesic medication (two button presses within a short time). This feature was recommended by participants at the first international workshop on PCA,¹⁵ but most current PCA systems require only a single button press; thus greater reliance is placed upon other safety features. Hybrid control of drug administration may decrease the safety of the technique unless the mandatory drug administration is at a low rate or possibly in the form of a decremental infusion;¹⁶ even when a modest fixed-rate supplementary infusion is used, e.g. morphine sulphate 2 mg/hour, ventilatory depression may occur.⁷ The conclusion of an audit of the first 200 patients who used PCA at a District General Hospital was that PCA may not be safe when used with a background infusion.¹⁷ The possibility that a safe (i.e. low-dose) fixed rate infusion might be ineffective was discussed at the PCA workshop¹⁵ and it was concluded that only clinical trials could resolve issues of comparative efficacy and safety. The minimum number of patients to test the hypothesis was calculated for this study (see above) because one treatment group was expected to be inferior to the other.

It has been suggested that acute tolerance to morphine may develop rapidly with opioid infusions and may lead to increased opioid requirements during the period of acute treatment.^{5,18,19} It is possible that tolerance may also develop acutely to emetic effects of opioids and in this study there was less nausea in patients who received an infusion even though they received twice as much morphine.

We have studied only morphine and have not attempted to extrapolate these results to other opioids. The adverse effects and pain relief afforded by techniques such as decremental infusions or decremental infusion-demands could be studied because of the potential for ventilatory depression with a fixed rate infusion.

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Suxamethonium—the relation between dose and response

R. J. CHESTNUT, T. E. J. HEALY, N. J. N. HARPER AND E. B. FARAGHER

Summary

In a study which involved 120 adult patients, the ED₅₀ of suxamethonium was shown to be 0.51 mg/kg, using an electromyographic technique. Marked individual variation in response was noted, for example a dose of 0.3 mg/kg produced a range of blockade from 4%–90%. Body surface area was shown to be more significantly related to blockade than lean body mass or total body weight.

Key words

*Monitoring techniques; electromyography.
Neuromuscular relaxants; suxamethonium.*

The intensity of neuromuscular blockade produced in separate patients by similar doses of suxamethonium is reported to be unpredictable and this uncertainty is reflected in the wide range of doses, from 10–40 mg and 1.0–2.0 mg/kg, that are recommended for an adult patient.^{1–7} Nonetheless, the relation between the dose of suxamethonium and the magnitude of blockade in adults measured mechanically or electromyographically, does not appear to be published. It would therefore be instructive to examine both the relation between the dose of suxamethonium and the magnitude of the resulting neuromuscular blockade and also those variables which might influence the constancy of response.

Method

Group A

One-hundred-and-twenty patients of ASA grades 1 and 2, aged 18–65 years were allocated, using a random sequence, to one of eight subgroups. Each subgroup was given a dose of suxamethonium within the range 0.2–0.6 mg/kg. Any patient with renal, hepatic or neuromuscular disease or taking medication known to affect the neuromuscular junction was excluded. All patients gave informed consent to the study which had been approved by the Hospital Ethics Committee.

Neuromuscular transmission was examined by stimulation of the ulnar nerve at the wrist, using surface electrodes, with a supramaximal square wave impulse of 0.2 msec duration, repeated every 15 seconds. The evoked compound

action potential (ECAP) of the *adductor pollicis* was detected and recorded on heat-sensitive paper using a portable electromyograph, Neuromatic 2000M (Dantec), which also generated the stimuli.

Premedication with papaveretum 10 mg and hyoscine 0.2 mg was given intramuscularly 90 minutes pre-operatively. A 10-ml sample of blood was taken before induction of anaesthesia. Plasma cholinesterase was assayed using the method described by Kalow and Lindsay.⁸ The patient was excluded from the study if an abnormal value for cholinesterase activity was subsequently found.

Anaesthesia was induced with thiopentone 4–5 mg/kg and maintained with nitrous oxide 70% in oxygen. Expired carbon dioxide concentration was measured and normocapnia was maintained by assisting ventilation when necessary. Three control values were noted after stable recordings of the ECAP had been established and then maintained for one minute. The preselected dose of suxamethonium was given intravenously preceded and followed by normal saline. The suxamethonium used in this part of the study was that which was normally available in the anaesthetic room. The ECAP of the *adductor pollicis* was monitored at 15-second intervals until maximum blockade was achieved. Percentage blockade was derived from measurement of the peak to peak amplitude of the ECAP.

Group B

A further group of 15 patients was studied using the same anaesthetic technique. These received 0.3 mg/kg of suxa-

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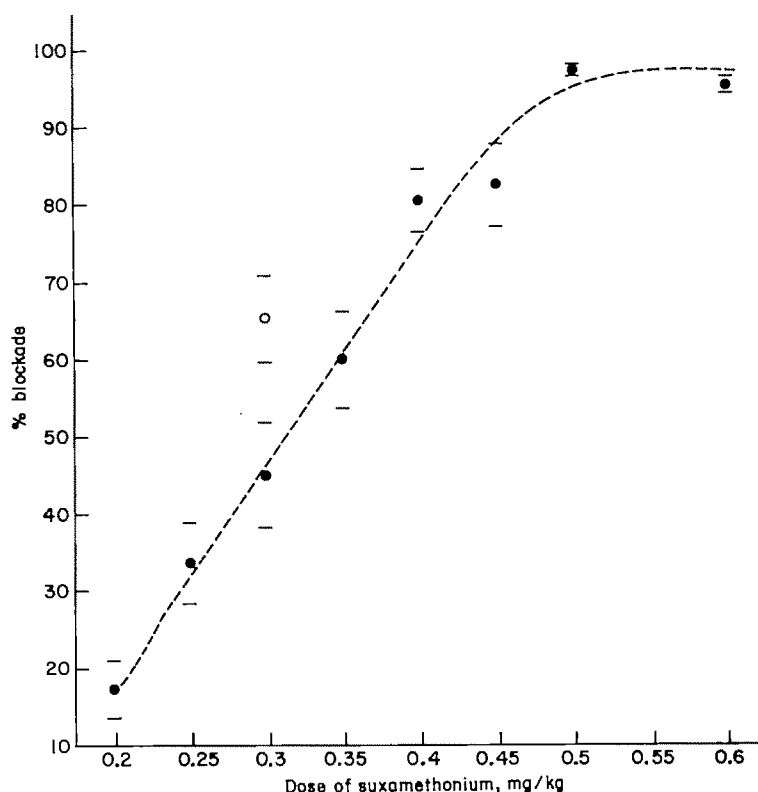


Fig. 1. Relation between dose of suxamethonium (mg/kg) and the percentage blockade of the *adductor pollicis*. ●, Group A 'hospital available' suxamethonium ($n = 120$); ○, Group B specially refrigerated suxamethonium ($n = 15$). Mean values (SEM) are shown.

methonium which had been refrigerated from manufacture to the time of injection. The patients' lean body mass, body surface area and circulation time were recorded. Lean body mass was estimated by measuring skin fold thickness, body surface area by reference to nomograms relating height, weight and surface area, and circulation time by measuring the time from injection of the drug to time of onset of fasciculation. A 10-ml sample of blood was taken before induction of anaesthesia to allow the plasma cholinesterase activity and dibucaine number to be assayed using the techniques described by Kalow.^{8,9}

Statistical analysis

Group A. The age and weight of the eight study groups were compared using one-way analysis of variance. The relation between dose of suxamethonium and response was examined by fitting a series of linear regression models using the method of maximum likelihood.¹⁰ The responses did not follow a normal distribution because they were expressed as % blockade. A number of statistical transformations were considered, but most were rejected because they failed to accommodate the restriction that the response variable could not extend beyond 0 and 100%. The best fit to the data while observing this constraint was found by assuming a linear relationship between dose and logit (response) where:

$$y = \text{logit (response)} \\ = \log_e (\% \text{ blockade} / (100 - \% \text{ blockade}))$$

The adequacy of this fit was confirmed by the construction of a half-Normal probability plot of the model

residuals.¹¹ The results of these model fits have been detransformed into the original units for presentation; this shows the essential curvilinear relationship between dose and response. Confidence limits for the response at each dose studied were calculated: again, these have been detransformed to the original units and so are not symmetrical about the (detransformed) mean response. ED values (and their confidence intervals) for 50% and 95% were calculated directly from the regression model fitted to the data.¹¹

Group B. Response was transformed to logits as for group A and its mean (and 95% confidence interval) calculated. The relation between logit (response), body surface area, total body weight, lean body mass and time to fasciculation was examined by fitting a series of multiple linear regression models by the method of maximum likelihood.¹⁰ The computations were all carried out using the G21M 3.77 statistical computer package.¹² Significance was set at the conventional 5% level throughout.

Results

Group A

There were no significant differences between the patients in the eight treatment subgroups with respect to age and weight (Table 1). The relation between dose and response is shown in Figure 1, which also indicates the standard error of the mean (SEM) for the response observed at each dose level studied. A wide individual variation was noted, particularly at the intermediate doses (0.25–0.45 mg/kg). The magnitude of neuromuscular blockade ranged from 4–

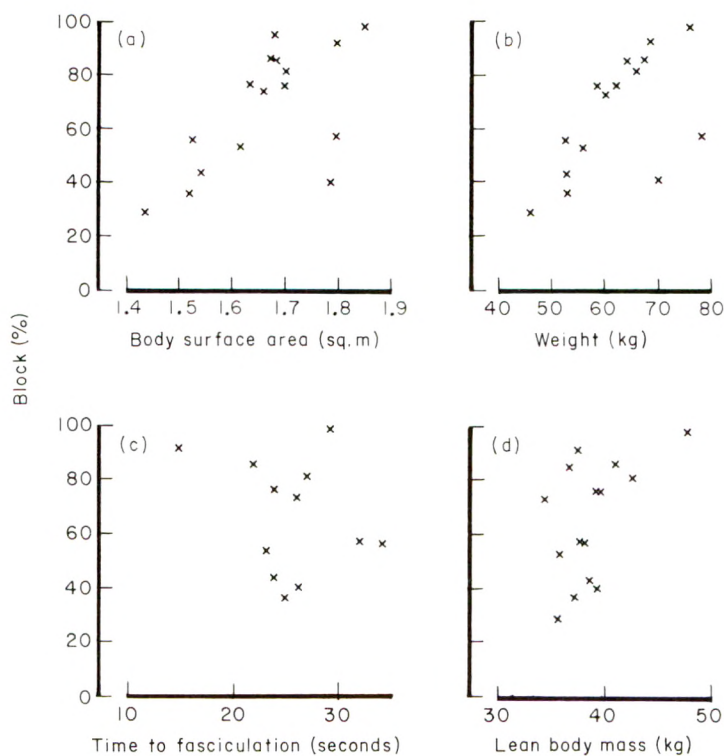


Fig. 2. The relation between (a) body surface area and percentage blockade ($r = 0.675$); (b) total body weight and blockade ($r = 0.625$); (c) circulation time, as measured by time from injection of suxamethonium to fasciculation ($r = 0.230$) and blockade and (d) lean body mass and blockade ($r = 0.657$) in the patients in Group B, that is those who received 0.3 mg/kg of refrigerated suxamethonium ($n = 15$).

Table 1. Patient characteristics.

Group	Number	Mean age, years (SEM)	Mean weight, kg (SEM)
1	15	39.9 (3.56)	60.2 (2.25)
2	15	36.9 (1.86)	56.8 (2.43)
3	15	38.4 (3.30)	61.8 (2.12)
4	15	34.9 (2.68)	60.2 (1.88)
5	15	41.6 (4.26)	64.9 (2.14)
6	15	37.6 (2.17)	63.0 (2.40)
7	15	32.4 (2.27)	60.9 (1.32)
8	15	37.6 (2.56)	60.7 (2.42)

90% and from 84–99% respectively at doses of 0.3 mg/kg and 0.6 mg/kg. The ED_{95} for suxamethonium was calculated to be 0.51 mg/kg with a 95% confidence interval of 63.3 to 99.6%. The ED_{50} was 0.31 mg/kg.

Group B

The blockade ranged from 28–98% in those patients who were given 0.3 mg/kg of refrigerated suxamethonium. The range was similar to that induced by the same dose in Group A, but the mean change in response was greater than that achieved by 0.3 mg/kg of hospital available suxamethonium. The mean response and its SEM are also shown in Figure 1. The lack of overlap with the confidence limit for the corresponding dose of hospital available suxamethonium indicates that this difference was statistically significant.

A significant relationship was found between body surface area, lean body mass, total body weight ($p = 0.006$,

$p = 0.008$ and $p = 0.013$ respectively) and the response to a given dose (0.3 mg/kg) (Fig. 2a, 2b, 2d). Nonetheless, even body surface area was a poor predictor of neuromuscular blockade with confidence limits of $\pm 40\%$. No relation was shown between circulation time, measured using the time from injection to fasciculation and response (Fig. 2c).

Discussion

Durrant and Katz suggested that the relation between dose and response for suxamethonium was of academic interest only.¹³ However, values for the ED_{50} and ED_{95} of muscle relaxants are important because a knowledge of these doses allows comparisons to be drawn between the responses of the separate muscle relaxants. The relation between dose of suxamethonium and response, measured electromyographically, does not appear to be published.

Published studies have examined the response to intramuscular injection¹⁴ or to intravenous infusion of suxamethonium;^{15,16} two techniques which are used infrequently. The end point has been ill-defined in these and other studies that have been designed to relate dose with response; cessation of respiration or presence of fasciculation.^{15,16} Some investigators have examined the duration rather than the degree of blockade and in so doing have used doses which produce maximum blockade.¹⁷ Schuh and colleagues have published a cumulative dose response curve for suxamethonium,¹⁸ but it has been suggested that a cumulative technique is inappropriate for a study of the action of drugs with a brief action.^{19,20} The predominant feature of all the studies is the large variation in blockade.^{14–17,21–23}

In the present study the $ED_{0.5}$ for suxamethonium, determined electromyographically, was 0.51 mg/kg and the ED_{50} was 0.31 mg/kg. At 0.3 mg/kg (approximately ED_{50}) the variation in the degree of neuromuscular blockade was marked. The variation in response was reflected in the wide confidence interval, and therefore must question the sensitivity of other studies which report the effect of other anaesthetic agents on the intensity of blockade as a result of small doses of suxamethonium.¹⁸

Many anaesthetists consider that the clinical variation in response to suxamethonium is because of spontaneous degradation of the drug, which occurs when it has been stored inadvertently at room temperature. The evidence cited by the manufacturers, however, suggests that the reduction in potency of suxamethonium kept at room temperature is of the order of 10% over 4–5 months. The mean blockade recorded in those patients given the refrigerated suxamethonium was significantly greater than that provided by the hospital drug, but the range in the blockade was still very wide (28–98%). Therefore, while degradation may have contributed to the inconsistency of the responses to the hospital drug, it is unlikely to be the only factor responsible for the variability in the response to suxamethonium.

It has been suggested that a slow circulation leading to hydrolysis before the drug reaches the neuromuscular junction could be one factor in reducing the expected blockade and therefore in contributing to the variability in response to a given dose.^{24,25} Time from injection of the drug to onset of fasciculation has been reported to give an indication of circulation time^{24,26} and was used in this study to examine the relation between circulation time and the variation in response. The results presented here do not support the view that circulation time is an important factor in determining the degree of response.

Those patients with atypical cholinesterase values were excluded from the study, but the degree of neuromuscular blockade produced in them ($n = 14$) was within one standard deviation at any dose. A difference in plasma cholinesterase level is therefore unlikely to contribute to the unpredictability of effect.

The relation between body surface area and block at a dose of 0.3 mg/kg was more significant than that between lean body mass or total body weight and blockade. These findings are in agreement with the work of Cook and Fischer who suggest that the degree of neuromuscular blockade achieved in children for a given dose is related to body surface area. This explains the apparent resistance of children to suxamethonium and the variation in response found in children of different ages.^{13,27} Consideration must be given to other factors that might contribute to the variation in response. These could include the volume of distribution, plasma protein binding and receptor protein binding, factors which are more difficult to explore.^{14,21,28} It is surprising that lean body mass, a measurement most likely to reflect muscle mass, was not more closely related than body surface area to blockade.

The lack of constancy in the response to suxamethonium makes it difficult to predict with any accuracy the effect of a small dose of suxamethonium in an adult patient. This is an important consideration for those clinical situations in which a small dose of suxamethonium is commonly used, for example for electroconvulsive therapy or in the self-taming technique.²⁹

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Intravenous regional anaesthesia of the arm

Effect of the technique of exsanguination on the quality of anaesthesia and prilocaine plasma concentrations

J. HAASIO, S. HIIPPALA AND P. H. ROSENBERG

Summary

The effects of different techniques of exsanguination of the upper arm during intravenous regional anaesthesia on prilocaine plasma concentrations, quality of anaesthesia, toxic symptoms after deflation of the tourniquet and injection pressure of the anaesthetic were studied in 10 healthy male volunteers. The nondominant arm was exsanguinated using either Esmarch's bandage or elevation of the arm for 2 minutes plus arterial occlusion by compression of the brachial artery. The injection pressure after the prilocaine dose (3 mg/kg) was significantly higher in the elevation group (maximally 98 mmHg). There were no statistically significant differences in the onset of, or recovery from, anaesthesia between the groups. Various mild toxic symptoms, were experienced in the central nervous system after deflation of the tourniquet. However, there was no correlation between the two techniques and the degree of severity of the toxic symptoms. The highest single venous plasma concentration (total) of prilocaine was 2.3 µg/ml measured from the contralateral cubital vein (elevation group, 2 minutes). The differences in prilocaine concentrations between the groups were not statistically significant.

Key words

Anaesthetics, local; prilocaine.

Anaesthetic techniques; regional.

The importance of good exsanguination and a correctly functioning pneumatic tourniquet for the achievement of effective and safe intravenous regional anaesthesia (IVRA) of the arm has been emphasised by several authors.^{1,2} Usually a tight Esmarch rubber bandage is used to displace blood from the extremity before injection of the local anaesthetic. Exsanguination is often attempted by elevation and simultaneous compression of the main artery, in the event of painful trauma, possibly at the expense of the quality of the block.^{1,2} These two methods of exsanguination and their relation to anaesthetic parameters have not been compared under controlled conditions, and so a crossover study was performed on IVRA of the arm with prilocaine in volunteers.

Methods

Ten healthy male volunteers, 24–43 years of age, participated in a randomised, crossover study which had been approved by the hospital ethics committee. No premedication was used. Two treatments at intervals of no less than one week were given in a random fashion.

The subjects were supine; the ECG was monitored continuously and arterial blood pressure was recorded with an oscillotonometer every 5 minutes during the experiments. The nondominant (always left) arm was exsanguinated and

the tourniquet applied using either Esmarch's bandage or elevation of the arm for 2 minutes plus arterial occlusion by compressing the brachial artery so that the radial pulse was absent for 2 minutes. A 7-cm wide tourniquet around the upper arm was then inflated to 300 mmHg for 20 minutes. Prilocaine 0.5%, 3 mg/kg was injected into a dorsal vein of the hand at a rate of 20 ml/minute immediately after exsanguination. The peak pressure in the basilic vein was recorded (14-gauge cannula). Blood haemoglobin concentration was determined before exsanguination and 15 minutes after cuff inflation (5 ml sample from basilic vein of the exsanguinated arm) to obtain an indirect measure of the degree of exsanguination of the arm.

Sensitivity to pinprick and blunt touch (the sharp end and the hub of a 27-gauge needle) was tested 2.5, 5, 7.5, 10, 12.5, 15 and 20 minutes after injection of prilocaine or deflation of the cuff at three locations as shown in Figure 1. Blood samples were taken for prilocaine assay³ from a cubital vein of the contralateral arm just before the test, 15 minutes after cuff inflation, and 2, 5, 10 and 20 minutes after deflation of the tourniquet. The samples were centrifuged and the plasma separated and frozen at –20°C until assayed. Subjective and objective evidence of toxicity during deflation was noted by the subject or the observer, or both.

A two-tailed *t*-test for pair differences was used for sta-

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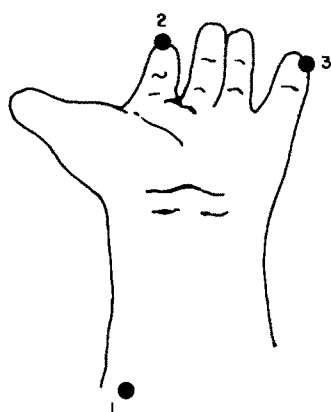


Fig. 1. Pinprick test sites. 1. Musculocutaneous nerve; 2. Median; 3. Ulnar.

tistical analysis. $P < 0.05$ was considered significant. All values are reported as mean (SEM). The Mann-Whitney U test was used for the evaluation of nonparametric correlations.

Results

Exsanguination and injection pressure

Visually, the arms exsanguinated with the rubber bandage remained pale even after the local anaesthetic injection, but when the exsanguination had been carried out with elevation and artery compression, the arms turned a mottled, cyanotic colour.

The haemoglobin concentration in the fluid from the cubital vein after 15 minutes of exsanguination was 71.4 (13.4) g/litre in the elevation group and 17.2 (4.6) g/litre in the Esmarch group. The difference was statistically significant ($p = 0.0012$). The starting pressure, that is, the pressure before any of the anaesthetic solution had been injected, was significantly higher in the elevation group; 19.6 (4.5) mmHg as compared with 1.5 (0.8) mmHg in the Esmarch group ($p = 0.0009$). The injection pressure after the prilocaine dose was significantly higher in the elevation group; 58.7 (5.9) mmHg (maximum, 98 mmHg) as compared with 30.9 (2.7) mmHg (maximum, 45 mmHg) in the Esmarch group ($p = 0.0005$) (Fig. 2).

Effects on sensation

There were no statistically significant differences in the onset of analgesia (that is, pinprick not felt), which varied from 2.5–20 minutes at the different spots, between the groups. The mean times to anaesthesia (that is, blunt touch not felt) in the elevation and the Esmarch group were 5 (2) and 6 (2) minutes (point 1), 7 (1) and 7 (1) minutes (point 2) and 10 (3) and 7 (1) minutes (point 3), respectively. There were no statistically significant differences between these values, except for point 3, where the onset of anaesthesia was slightly more rapid in the Esmarch group than in the elevation group ($p = 0.049$). There were no statistically significant differences between the mean times of recovery from complete anaesthesia to perception of blunt touch. The mean times of complete recovery in the elevation and the Esmarch group were 8 (2) and 7 (1) minutes (point 1), 12 (5) and 9 (2) minutes (point 2), 5 (1) and 7 (1) minutes

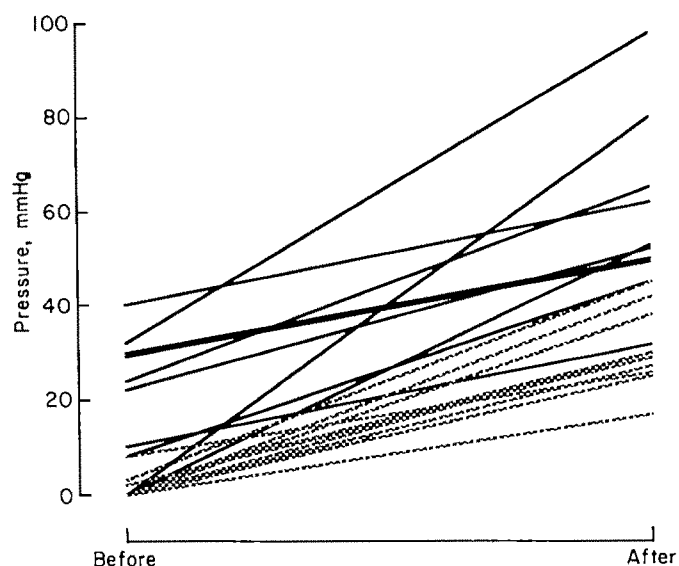


Fig. 2. Basile vein pressure before and after injection of the local anaesthetic, (mmHg). —, elevation; ---, Esmarch.

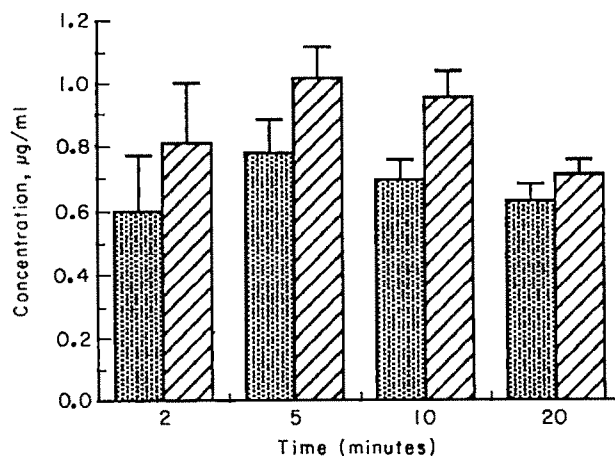


Fig. 3. Mean (SEM) prilocaine plasma concentrations, ($\mu\text{g/ml}$). □, elevation; ▨, Esmarch.

(point 3), respectively. The differences were not statistically significant.

CNS symptoms after deflation

Various mild CNS symptoms (dizziness, lightheadedness, auditory disturbances) were experienced after cuff deflation by seven volunteers in the elevation group and eight in the Esmarch group. The symptoms appeared within 30 seconds and disappeared within 7 minutes.

Prilocaine concentrations

The mean prilocaine plasma concentrations are shown in Figure 3. The highest single venous plasma concentration of prilocaine, after 2 minutes of deflation, was 1.72 $\mu\text{g/ml}$ in the elevation group and 2.26 $\mu\text{g/ml}$ in the Esmarch group. There were no statistically significant differences between the groups. The prilocaine plasma concentrations were similar in the volunteers who did not perceive any CNS toxicity symptoms to those who did have symptoms. ECG was normal and arterial blood pressure remained stable throughout each experiment.

Discussion

The results indicate that the two techniques of exsanguination did not differ with respect to the quality of anaesthesia obtained by ischaemia and 0.5% prilocaine. The main difference between these two techniques was the amount of blood that remained in the arm. This was clearly demonstrated visually and by comparing the haemoglobin values in the fluid sampled from a cubital vein before tourniquet cuff deflation.

The relatively slow injection speed (20 ml/minute) increased the cubital vein pressure markedly when elevation plus compression was used for exsanguination. However, even the highest individual peak pressure, 98 mmHg, remained safely below the tourniquet occlusion pressure of 300 mmHg. The absence of local anaesthetic leakage under the cuff was confirmed by a lack of prilocaine in the circulating blood during the tourniquet inflation period. A more rapid injection speed, even into a distal vein, may increase the intraluminal pressure to such an extent that considerable amounts of local anaesthetic can enter the circulation.^{4,5} On the other hand, the increased intraluminal venous pressure probably causes additional extravasation of the local anaesthetic, and thereby enhances the block intensity at adjacent nerve endings. Mild toxic CNS symptoms occurred in almost every subject. No correlation was observed between prilocaine plasma levels and symptoms, as in earlier studies.⁶ In fact, the plasma levels of the volunteers who did not experience any CNS toxicity symptoms were similar to those who did have symptoms. It is clear that the lungs take up a considerable amount of prilocaine during the first passage,⁷ and this provides protection against severe intoxication.

In conclusion, comparative anaesthetic conditions can be

achieved by using either elevation plus the arterial compression technique, or Esmarch's technique. The main difference between the two techniques is the excess of blood that remains in the arm when elevation is used. Rapid injection may increase intraluminal pressure to such an extent that leakage of the local anaesthetic under the tourniquet cuff occurs and severe toxicity ensues.⁵

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Efficacy of lignocaine in the suppression of the intra-ocular pressure response to suxamethonium and tracheal intubation

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Summary

The effect of lignocaine pretreatment on the intra-ocular pressure response to suxamethonium and tracheal intubation was studied in 80 adult patients, divided randomly into four groups of 20 each. These groups received respectively normal saline (10 ml), lignocaine 1 mg/kg, 1.5 mg/kg and 2 mg/kg as pretreatment, in a double blind manner, one minute before anaesthetic induction with thiopentone and suxamethonium 1.5 mg/kg. Lignocaine pretreatment caused a significant decrease in intra-ocular pressure. Suxamethonium caused a significant increase, but lignocaine pretreatment in doses of 1.5 mg/kg and 2 mg/kg effectively kept the postsuxamethonium pressure below control values. Tracheal intubation further aggravated the postsuxamethonium increase in intra-ocular pressure. Lignocaine, in doses of 1.5 mg/kg and 2 mg/kg also effectively kept the postintubation pressure values below control levels. Lignocaine, in dose of 1 mg/kg, only partially attenuated the postsuxamethonium and postintubation increase in intra-ocular pressure. In conclusion, lignocaine pretreatment, in a dose of 1.5 mg/kg, offers protection against suxamethonium- and tracheal-intubation initiated increases in intra-ocular pressure, without causing any significant decrease in arterial pressure.

Key words

Anaesthesia; ophthalmic.

Complications; increased intra-ocular pressure.

Suxamethonium administration causes a transient but significant increase in intra-ocular pressure (IOP).¹ This is further increased after tracheal intubation.² Some authors³ advocate a pancuronium, thiopentone and atropine drug sequence to avoid the use of suxamethonium for rapid intubation in children with full stomachs in whom an increase in IOP is undesirable. However, the need to make suxamethonium safe to use in cases with penetrating eye injuries continues because it remains the drug of choice for rapid intubations.^{4,5}

Intravenous lignocaine reduces anaesthetic requirement⁶ and prevents fasciculations after suxamethonium.⁷ It attenuates the reflex circulatory responses to laryngoscopy and intubation.⁸ It is also effective against the increase in intracranial pressure which follows tracheal intubation in patients with brain tumours.⁹ Pretreatment with lignocaine, in a dose of 1 mg/kg, is reportedly sufficient to prevent the IOP increase associated with tracheal intubation. This dose of lignocaine (1 mg/kg) was more effective than either tubocurarine or diazepam in the prevention of an IOP increase after suxamethonium but it failed to prevent the rise completely.¹⁰ This study was designed to test the efficacy

of lignocaine, in three different doses, to suppress the IOP response after suxamethonium administration and tracheal intubation.

Methods

The study was carried out in a double blind fashion. Eighty patients, of both sexes aged 15-50 years, ASA group 1, without any eye ailment and scheduled for elective surgery unrelated to the eye, were selected. The procedure for measurement of IOP was explained and informed consent obtained. All patients were premedicated with pethidine 1.5 mg/kg and promethazine 0.4 mg/kg intramuscularly one hour before anaesthesia and were allocated to one of the four groups with the help of a random numbers chart. Pretreatment with one of the following was given intravenously one minute before induction of anaesthesia: group 1, normal saline 10 ml; group 2, lignocaine 1 mg/kg; group 3, lignocaine 1.5 mg/kg; group 4, lignocaine 2 mg/kg.

The pretreatment drug was prepared by a worker not connected with the execution of procedure and the volume of drug in all the groups was diluted to 10 ml. Intravenous

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induction was carried out, one minute after pretreatment, with sufficient thiopentone to obtund the eyelash reflex, followed by suxamethonium 1.5 mg/kg. Meanwhile ventilation was assisted or controlled with a facemask, using a Bain-type anaesthetic breathing system that delivered 33% oxygen in nitrous oxide at a fresh gas flow of 100 ml/kg body weight.¹¹ Laryngoscopy and tracheal intubation were performed, and took no more than 30 seconds, after the onset of apnoea. Inhalational supplements or topical lignocaine spray were avoided during the induction sequence.

Measurements of IOP, systolic arterial pressure (Korotkoff's method using sphygmomanometer) and heart rate (cardiac monitor) were made with the patient supine and with the operating table flat, at the following intervals: before pretreatment (basal value); one minute after pretreatment, just before induction; after injection of thiopentone and suxamethonium, immediately following the cessation of fasciculations or 45 seconds after administration of suxamethonium if no fasciculations were visible; immediately after intubation and then every 2 minutes until the effect of suxamethonium began to wear off. All measurements of IOP were made by an ophthalmologist using a Schiotz tonometer (technique accurate to within (\pm) 2 mmHg).^{12,13} Readings were taken in both eyes of each patient after topical administration of three drops of 4% lignocaine. The mean of the two readings was recorded. At no time did the measurement of IOP interfere with the progress of the anaesthetic. Student's *t*-test for paired observations was used for analysis within groups and for unpaired observations for analysis between groups.

Results

All four groups were comparable on the basis of age, body weight, resting IOP, pulse rate and systolic arterial pressure (SAP) (Table 1). The changes in IOP during the induction sequence are shown in Figure 1. Lignocaine pretreatment in groups 3 and 4 produced a highly significant decrease in IOP ($p < 0.001$). However, IOP increased significantly after the administration of suxamethonium in groups 1 ($p < 0.001$) and 2 ($p < 0.01$), whereas it remained significantly lower than the basal values in groups 3 ($p < 0.05$) and 4 ($p < 0.001$). Tracheal intubation caused a further increase in IOP in groups 1 and 2 ($p < 0.001$), whereas group 4 maintained significantly low IOP values (as compared to basal) even after intubation ($p < 0.001$). There was no significant change in IOP in group 3 after intubation compared with basal, as well as postsuxamethonium, values. The increase observed in group 2 after tracheal intubation was significantly less than the increase observed in the control group.

Systolic arterial pressure (SAP) decreased significantly after induction drugs in group 4 ($p < 0.001$) whereas there was no significant change in SAP in the other three groups.

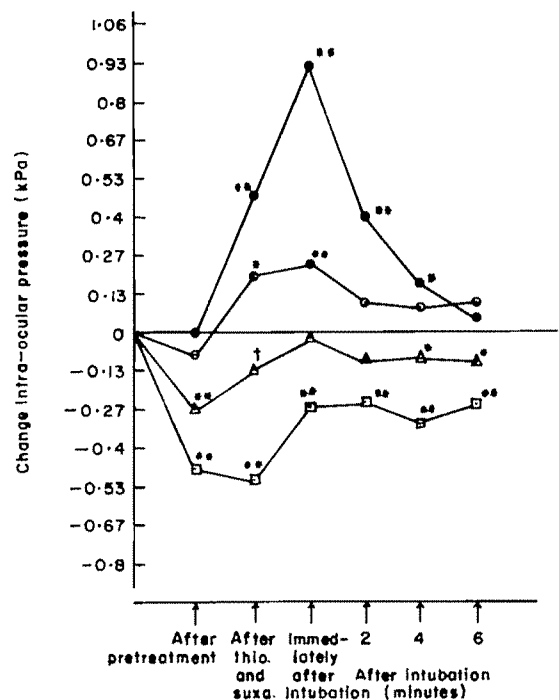


Fig. 1. IOP change from basal values at various intervals. Significant changes in IOP are indicated: † $p < 0.05$; * $p < 0.01$; ** $p < 0.001$. ●—●, control; ○—○, lignocaine 1 mg/kg; △—△, lignocaine 1.5 mg/kg; □—□, lignocaine 2 mg/kg.

Intubation caused a significant increase in SAP in groups 1 ($p < 0.01$) and 2 ($p < 0.05$) whereas SAP remained significantly lower than the basal ($p < 0.001$) even after intubation in group 4 (Fig. 2).

Discussion

A number of studies have revealed that suxamethonium causes an increase in IOP,^{1,2,14} but the exact mechanism remains uncertain. Contracture of extra-ocular muscles¹⁵ and dilatation of choroidal blood vessels¹⁶ were suggested as responsible. This increase in IOP after suxamethonium, which is aggravated further by tracheal intubation,^{2,17} may be secondary to a sudden increase in arterial pressure,¹² straining¹⁸ or reflex venospasm.¹⁹

A number of methods of pretreatment have been suggested, in an attempt to prevent the suxamethonium-induced increase in IOP. These include small doses of competitive neuromuscular relaxants,²⁰ 'self taming' small doses of suxamethonium²¹ and drugs such as hexafluorrenium,²² acetazolamide²³ and diazepam,²⁴ but none of these methods was found to be satisfactory.²⁵⁻²⁸ Pretreatment with intravenous lignocaine was reported to attenuate the haemodynamic responses to laryngoscopy.⁸ However, the efficacy of such a pretreatment to prevent

Table 1. Mean (SEM) resting values in each group.

	Group 1 control (<i>n</i> = 20)	Group 2 lignocaine 1 mg/kg (<i>n</i> = 20)	Group 3 lignocaine 1.5 mg/kg (<i>n</i> = 20)	Group 4 lignocaine 2 mg/kg (<i>n</i> = 20)
Age, years	29.4 (1.9)	31.5 (2.0)	32.4 (1.7)	30.3 (1.6)
Body weight, kg	54.4 (2.5)	54.1 (2.1)	55.8 (1.9)	53.1 (1.8)
IOP, kPa	2.3 (0.07)	2.3 (0.05)	2.4 (0.05)	2.4 (0.04)
Pulse rate, beats/minute	84.5 (2.6)	86.0 (3.0)	84.2 (1.9)	88.3 (2.6)
Systolic blood pressure, mmHg	121.4 (2.0)	126.6 (3.1)	125.3 (2.5)	119.0 (2.4)

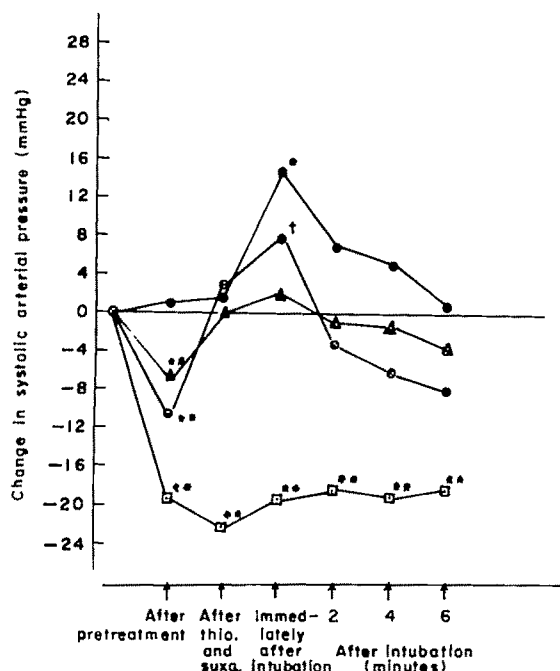


Fig. 2. SAP change from basal values at various intervals. Significant changes in SAP are indicated: † p 0.05; * p 0.01; ** p 0.001. ●—●, control; ○—○, lignocaine 1 mg/kg; △—△, lignocaine 1.5 mg/kg; □—□, lignocaine 2 mg/kg.

suxamethonium- and tracheal-intubation induced increases in IOP is still a subject of discussion.^{3,29} Recently, we have reported that pretreatment with lignocaine (1 mg/kg) is more effective than either tubocurarine or diazepam in the prevention of an IOP increase after suxamethonium and/or tracheal intubation.¹⁰

Our results show that lignocaine pretreatment in doses of 1.5 mg/kg and 2 mg/kg offers complete protection against suxamethonium-induced increase in IOP (Fig. 1). There was a significant increase in IOP after suxamethonium ($p < 0.01$), when lignocaine in a dose of 1 mg/kg was used, but this was significantly less than that observed in the control group. The observed efficacy of lignocaine in the reduction of postsuxamethonium IOP increase may be explained on the basis of the proposed peripheral actions of lignocaine.³⁰

We also found intravenous lignocaine to be effective pretreatment in preventing the increase in IOP after tracheal intubation in groups 3 and 4. The pressure remained below basal values immediately after intubation in these groups, when the maximum increase in IOP can be expected to occur (Fig. 1). This might have been as a result of an obtunded haemodynamic response,⁸ suppressed cough reflex³¹ and increased depth of anaesthesia after lignocaine pretreatment. Lerman and Kiskis³ also used lignocaine 1.5 mg/kg to attenuate IOP response to intubation in children, but they used a pancuronium, thiopentone and atropine drug sequence for induction of anaesthesia. Our results contradict Smith *et al.*²⁹ who concluded that lignocaine in doses of 1–2 mg/kg is ineffective in preventing the increase in IOP after suxamethonium and/or tracheal intubation. Basal IOP readings in their study were taken after administration of thiopentone which itself is known to decrease IOP;³² this made it difficult to find whether the increase observed with suxamethonium and/or tracheal intubation significantly exceeded the prethiopentone value. Moreover,

they did not take IOP readings between suxamethonium and tracheal intubation; this made it difficult to define whether the increase was because of suxamethonium or tracheal intubation or both.

We were unable to monitor arterial carbon-dioxide tension. Changes in arterial carbon-dioxide may alter IOP³³ but these were probably unimportant during the short period of this study, throughout which the patients were ventilated using a Bain-type anaesthetic system.

It is evident from Figures 1 and 2 after correlating SAP and IOP, that the extent of IOP and SAP changes after suxamethonium and tracheal intubation are poorly related. SAP changes were minimal while IOP increased significantly in group 1 (control). All three study groups showed that an increase in both IOP and SAP after tracheal intubation was blunted. Hence we are of the opinion that a sudden increase in arterial pressure after tracheal intubation can lead to acute IOP changes.

We conclude that lignocaine pretreatment in a dose of 1.5 mg/kg is sufficient to prevent the IOP increase associated with suxamethonium and tracheal intubation. Pretreatment with lignocaine in a dose of 2 mg/kg, although it keeps IOP significantly below basal values throughout the period of study, also produces a significant decrease in systolic arterial pressure.

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CASE REPORT

Apnoea after retrobulbar block

J. D. RIGG AND R. H. JAMES

Summary

Two cases of apnoea after retrobulbar block for cataract surgery are described. The possible causes and mechanisms of this complication, its detection and management are discussed.

Key words

Anaesthetic techniques, regional; retrobulbar.

Complications; apnoea.

Local anaesthesia is used widely for intra-ocular surgery in the elderly, because of the rapid recovery and in the belief that complications are reduced. In Leicester, approximately 50% of cataract surgery is performed under local anaesthesia.

The eye is anaesthetised in several stages.¹ The conjunctiva and cornea are anaesthetised with topical agents, e.g. amethocaine, administered pre-operatively. The facial nerve is blocked to prevent blinking, which impedes the performance of surgery and increases intra-ocular pressure. Retrobulbar block is performed to anaesthetise the sensory nerves from the iris which pass through the ciliary ganglion and the motor nerves that supply the extra-ocular muscles. Occasionally, the superior rectus requires individual blockade to achieve akinesia. In addition, many surgeons prefer patients to be sedated to prevent restlessness during microscopic surgery.

Apnoea after retrobulbar block is a recognised but rare complication. Two of our patients developed this complication, which may be preventable by modification of the technique.

Case histories

Case 1

An 85-year-old woman who weighed 45 kg was admitted for elective extracapsular cataract extraction and insertion of an intra-ocular lens. Previous cataract surgery under general anaesthesia had been followed by restlessness. In addition, she had suffered a myocardial infarction 6 months previously, and subsequently developed angina on climbing stairs. Consequently, it was decided that surgery should be

performed under local anaesthesia with intravenous sedation.

No premedication was given although the patient received a combination of tropicamide 1%, phenylephrine 10%, cyclopentolate 1% and amethocaine eye drops for conjunctival anaesthesia. The patient was given intravenous fentanyl 30 µg and droperidol 1.5 mg (as Thalamonal) in the anaesthetic room. The surgeon performed local anaesthesia 3 minutes later using bupivacaine 0.5% with adrenaline 1:100 000; this comprised 5 ml for facial nerve block (Van Lint and O'Brien's method),¹ 4 ml for retrobulbar block and 1 ml for superior rectus block. A 40-mm 25-gauge retrobulbar needle was used to perform the retrobulbar block, and the patient was requested to look upwards before it was inserted.

The patient developed nystagmus and became restless 3 minutes after injection, during transfer into the operating theatre. Unconsciousness and apnoea followed rapidly. Her trachea was intubated and her lungs ventilated with 100% oxygen. Her systolic arterial pressure was 180 mmHg and her heart rate 180 beats/minute. She was given naloxone 0.2 mg on the assumption that fentanyl had caused the ventilatory arrest, but this had no effect. The possibility of some form of local anaesthetic toxicity was considered, and because it was thought that her hypertension and tachycardia were the result of the presence of a tracheal tube, general anaesthesia was induced with nitrous oxide 50% in oxygen, and isoflurane 0.5%–1%. Her hypertension and tachycardia settled rapidly, and it was decided that surgery should proceed.

The operation progressed uneventfully and was completed 45 minutes after the ventilatory arrest. The patient

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breathed spontaneously and had intact airway reflexes within 5 minutes of discontinuing anaesthesia. Her trachea was extubated and she was taken to the recovery area where she regained consciousness rapidly. Serial electrocardiograms and cardiac enzymes were performed postoperatively and were normal. She was discharged in good health after these investigations had been completed.

Case 2

A 79-year-old, 60 kg woman was admitted for extracapsular cataract extraction and insertion of an intra-ocular lens. She had requested a local technique because a previous general anaesthetic led to postoperative dizziness.

No premedication was given, but the patient received topical preparation as described in Case 1. Fentanyl 60 µg and droperidol 3 mg were given over 5 minutes in the anaesthetic room to produce sedation. She was then taken into the operating theatre where she breathed oxygen 4 litres/minute through a facemask; her electrocardiogram was monitored. Five minutes later, the surgeon performed local anaesthesia in the manner described above.

There was a delay before the operation started. The patient gradually lost consciousness approximately 10 minutes after completion of the retrobulbar block and her respiration slowed, despite attempts to rouse her. She became apnoeic one minute later and her heart rate decreased to 50 beats/minute. Her lungs were ventilated with 100% oxygen through an anaesthetic facemask. Her heart rate increased to 90 beats/minute; systolic arterial pressure was 140 mmHg. She began gradually to breathe and regain consciousness after 5 minutes. She was confused initially but was sufficiently cooperative for the operation to be undertaken under local anaesthesia.

Surgery was uneventful and her block worked well. Additional doses of fentanyl 40 µg and droperidol 2 mg were given for sedation, without problems. The postoperative course was normal. She could recall her operation but had no memory of losing consciousness. She was discharged home in good health.

Discussion

Apnoea after retrobulbar anaesthesia has been reported previously.²⁻⁴ Two possible mechanisms have been proposed to explain its occurrence. Rosenblatt *et al.*² reported a patient who developed apnoea immediately after retrobulbar block had been performed, and suggested that intravascular injection had occurred. A case was reported by Chang *et al.*³ in which apnoea developed 7 minutes after retrobulbar block; the authors suggested that apnoea occurred as a result of puncture of the dural sheath that surrounds the optic nerve, and that local anaesthetic diffused to the brainstem in the subdural space. Apnoea was delayed for 2 to 10 minutes in our patients; this supports the theory of subdural rather than intravenous injection. Lombard⁵ showed that radiographic contrast medium could be detected in the subdural space in three out of 150 cases of retrobulbar injection for orbitography. Nigue and Bennett⁶ described a case of brainstem anaesthesia after trigeminal block in which the clinical course was similar to that in our patients. Cerebrospinal fluid was not aspirated before injection in any of the cases reported, or in our cases. Severe cardiovascular collapse has not been reported. It is possible that the combination of fentanyl and droperidol could have resulted in apnoea in our patients. However, there was no

response to naloxone administration in the first patient, and the delay in onset of apnoea, together with the fact that further doses of fentanyl and droperidol were given uneventfully, makes this explanation unlikely in the second patient.

The most extensive analysis of apnoea after retrobulbar anaesthesia was undertaken by Wittpenn,⁴ who studied 3123 retrobulbar blocks prospectively. Nine cases of respiratory arrest occurred in which other causes of apnoea were excluded. A large majority (7/9) occurred in patients who received 4% lignocaine and 0.5% bupivacaine rather than 2% lignocaine and 0.5% bupivacaine. The authors concluded that the lowest effective dose of local anaesthetic solution should be used.

The length of the needle has not been implicated previously in connexion with the risk of apnoea. If subdural injection is the cause of apnoea, the risk of occurrence will be increased by the use of a long needle which penetrates more deeply into the orbit and by manoeuvres which pull the optic nerve and its sheath closer to the needle tip. Retrobulbar needles are 40 mm in length and are designed to deposit local anaesthetic around the ciliary ganglion, which is approximately 35 mm deep to the skin.⁷ Two other consultant ophthalmic surgeons in Leicester who perform large numbers of retrobulbar blocks use a shorter 30-mm, 23-gauge needle, and have not experienced any case of apnoea. Patients are often asked to look upwards and medially during performance of a retrobulbar block; this manoeuvre pulls the fascial sheath forward but it also pulls the optic nerve and sheath forward, and reduces the skin-to-subdural distance.

A matter of some concern is that detection of this complication may be delayed. Neither cerebrospinal fluid nor blood was aspirated in any of the reported cases. Apnoea is often delayed for several minutes, by which time the operation may be under way, the patient covered in surgical towels and the vigilance of the anaesthetist (if present) at its lowest. Monitoring of oxygen saturation with pulse oximetry may be valuable. Apnoea, once detected, is managed easily if staff skilled in airway management, and appropriate resuscitation equipment, are available. All the cases reported have survived in good health.

Acknowledgments

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CASE REPORT

Acute thyroid crisis on induction of anaesthesia

M. H. BENNETT AND A. P. WAINWRIGHT

Summary

Thyroid crisis on induction of anaesthesia was treated with dantrolene, because of a mistaken diagnosis of malignant hyperthermia. There was immediate improvement after dantrolene with reduction in muscle rigidity, mental confusion and pyrexia. High circulating T_4 has an effect on calcium flux across the sarcoplasmic reticulum and dantrolene may inhibit this pathological mechanism. We suggest the same dosage regimen as is used in the treatment of malignant hyperthermia.

Key words

*Hyperthermia; malignant.
Neuromuscular relaxants; dantrolene.*

An escalating pyrexia that develops in association with anaesthesia is fortunately a rare event. Rapid treatment is required although the cause may not be immediately apparent. Early descriptions in 1900¹ showed that during the first half of the century factors other than septicaemia or high ambient temperature were involved.² It was not until 1960 that the syndrome of malignant hyperpyrexia was described accurately.³ The incidence, reported as 1:40 000 in adults and 1:12 000 in children, is by far the most common reported cause of life-threatening hyperthermia during anaesthesia. It is a familial disease, triggered by suxamethonium and potent inhalation anaesthetics such as halothane. Susceptibility varies with age and patients may receive several anaesthetics before a clinical episode occurs. The temperature increases as a result of muscle contraction, at a rate of approximately 1°C every 5 minutes, and may go above 46°C, but the rise is a relatively late finding. The syndrome is manifested typically by tachycardia, increasing arterial blood pressure and tachypnoea.⁴

Pyrexia is always present in thyroid crisis and may be extreme. Other features are variable, but the usual clinical picture of hyperthyroidism is exaggerated. It is often precipitated by a complicating illness and may be the presenting event in a patient with previously undiagnosed or inadequately treated known hyperthyroidism.⁵

We report a case of thyroid crisis on induction of anaesthesia, treated with dantrolene after a presumptive diagnosis of malignant hyperthermia and describe the similarities that exist in the presentation of these two rare conditions and the rationale behind the use of dantrolene.

Case history

A 39-year-old male labourer was admitted with fractures of the lower tibia and fibula after an accidental fall at work. Routine history revealed no abnormality and his previous general anaesthetic, for tonsillectomy when he was 18 years old, was uneventful. Examination on admission was unremarkable. He was solidly-built and muscular with a florid complexion; weight 84 kg, pulse 60 beats/minute regular, arterial blood pressure 140/80 mmHg and oral temperature 36.5°C.

Orthopaedic management required the insertion of a pin through the os calcis for skeletal traction. Papaveretum 20 mg and hyoscine 0.4 mg by intramuscular injection were given one hour before surgery. The patient was lightly sedated and pain free on arrival in the anaesthetic room. Anaesthesia was induced with thiopentone 350 mg, but was stormy with bucking and straining on application of the mask, until a regular respiratory pattern was established with O₂ 3 litres/minute N₂O 6 litres/minute and halothane 2%. The patient then became flushed and tachypnoeic, with a palpable pulse of 200 beats/minute. An ECG and automatic blood pressure monitor were attached and revealed atrial fibrillation and an arterial blood pressure of 140/53 mmHg. The patient's skin now became mottled and blue. The inspiratory mixture was changed to 100% O₂ and the surgery performed immediately. Total exposure time to halothane had been 10 minutes.

The patient quickly regained consciousness but was confused and restless, with jerky and involuntary move-

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ments of his limbs. Skin colour improved and his respiratory rate decreased. His rectal temperature was 37.5°C and he had an irregular pulse, 145 beats/minute with a blood pressure of 148/84 mmHg. Blood results showed: Na⁺ 136 mmol/litre, K⁺ 4.8 mmol/litre and arterial blood gases revealed a mild metabolic acidosis with respiratory compensation, PaO₂ 13.4 kPa on 28% O₂ by Ventimask. Twenty minutes after cessation of anaesthesia the rectal temperature had risen to 38.7°C. The patient became more confused, hot, sweaty and flushed with uncoordinated jerking in all four limbs.

A provisional diagnosis of malignant hyperthermia was made and dantrolene 100 mg given by intravenous bolus. An intravenous infusion of glucose 20%, 1000 ml, with 25 units of insulin was started and the base deficit corrected with 8.4% sodium bicarbonate. He improved immediately, his oral temperature decreased to 37.2°C and he became less confused with decreased sweating and involuntary movement. A further 80 mg bolus of intravenous dantrolene was given. He was admitted to the intensive care unit. His condition remained stable, and treatment with dantrolene continued to a total of 450 mg over 4 hours. The rapid atrial fibrillation was treated with intravenous practolol 2.5 mg and digoxin 1.5 mg over 24 hours before an adequate control of the rate was obtained.

Twelve hours after anaesthesia he was still drowsy but fully orientated in time and place. He had a unilateral ptosis, a fine tremor of both hands and shoulder-girdle muscle wasting. His thyroid gland was small, firm and diffuse on palpation. The patient continued to deny any previous ill health but his wife considered him heat intolerant and subject to sweaty attacks with palpitations. Thyroid function tests confirmed the diagnosis of thyrotoxicosis, T₄ level of 57.9 picomol/litre (normal range 8.8–25 picomol/litre), urinary VMA levels were within normal range. Treatment with carbimazole, 60 mg per day and propranolol 120 mg daily controlled his symptoms and he was discharged 6 weeks after admission.

Discussion

Thyroid crisis is an exaggeration of all the signs and symptoms of thyrotoxicosis together with pyrexia, extreme irritability, restlessness, delirium or coma, vomiting and diarrhoea.⁵ This case demonstrates the marked similarities that exist between the clinical features of thyroid crisis and malignant hyperthermia. The increase in temperature, tachypnoea, mottling of skin with cyanotic areas, sweating and muscle stiffness, have been previously described in thyrotoxicosis mimicking malignant hyperthermia.⁶ The differential diagnosis may be difficult during anaesthesia and a previous uneventful anaesthetic, as in our patient, does not preclude the diagnosis of malignant hyperpyrexia.⁴

Both conditions include a metabolic acidosis, secondary to increased lactate production from skeletal muscle, and normal arterial oxygenation, unless ventilation is impaired by muscle rigidity.⁴ However, respiratory acidosis which is a feature of malignant hyperthermia⁴ was not present in our case. Peripheral cyanosis in malignant hyperthermia results from the decrease in mixed venous Po₂ after the sixfold increase in oxygen extraction by skeletal muscle;⁴ this was also a possible explanation for the cyanosis in our case.

The blood pressure is not a helpful diagnostic sign in thyroid crisis as both hyper- and hypotension occur; our patient remained normotensive. In fulminant cases of malignant hyperthermia the initially high blood pressure may decrease within 20 minutes as a result of the severe acidosis and development of shock. Atrial fibrillation is common in thyroid crisis whereas sinus tachycardia, ventricular arrhythmias or atrioventricular conduction defects are reported in malignant hyperthermia.⁴ It may be difficult to differentiate tachyarrhythmias with heart block on an electrocardiogram.

The development of thyroid crisis in association with anaesthesia is now rare because of prior treatment to bring circulating levels of T₄ to normal. This is achieved by prevention of hormone synthesis and blocking release of stored hormone with carbimazole, propylthiouracil and potassium iodide⁷ and antagonising the effects of already circulating hormone with beta-adrenoceptor blockade, digoxin, chlorpromazine, diuretics, and general measures such as tepid sponging.⁵ This case suggests that dantrolene may be useful in the treatment of hyperpyrexia associated with thyroid crisis in addition to its well defined role in the treatment of malignant hyperthermia.

Both malignant hyperthermia and thyrotoxicosis are hypermetabolic states and the production of excess heat is in both cases a result of skeletal muscle overactivity. The pathogenesis of malignant hyperthermia has been described⁴ but the precise defect has not been identified. The action of thyroxine on skeletal muscle is also imperfectly understood, in common with other target organs there is an elevation of metabolic rate. This has been demonstrated in animal models, pretreated *in vivo* with triiodothyroxine, through increased oxygen consumption mediated by increased Na-K-ATPase activity.⁸ Other work has demonstrated enhanced ATP-supported calcium transport and maximal calcium storage capacity in the sarcoplasmic reticulum of rabbit soleus muscles.⁹ This enhanced calcium flux at the sarcoplasmic reticulum, which has been implicated in association with high circulating thyroxine levels, is the biochemical area postulated for the antipyretic action of dantrolene.

Dantrolene is structurally similar to both hydantoin-derived anticonvulsants and the local anaesthetics. It appears to exert its therapeutic effect by inhibition of the excitation-contraction coupling process and possibly by direct inhibition of the release of calcium by the sarcoplasmic reticulum.^{10,11} There is little effect on normal muscle but there is a marked inhibition of contraction in the susceptible muscle of patients with malignant hyperthermia.^{4,10} In our case dantrolene exerted similar inhibitory effects which resulted in clinical improvement with a reduction in muscular activity, pyrexia and respiratory rate. Dantrolene has been suggested as treatment for the suppression of supraventricular arrhythmias by calcium antagonism,¹² but our patient required beta-adrenoceptor blockers and digoxin to control his fast atrial fibrillation.

The recommended dosage of dantrolene in malignant hyperthermia is an intravenous bolus of 1 mg/kg as soon as the diagnosis is suspected, with continued administration until symptoms subside or a cumulative dose of 10 mg/kg is reached. Side effects are not a common problem in the acute situation but in more prolonged administration may result in muscular weakness, drowsiness and general

malaise. Hepatotoxicity has been reported with long-term administration for spastic disorders.¹³

The similarity of presentation and skeletal muscle abnormality in both malignant hyperthermia and thyroid crisis on induction of anaesthesia suggest the same treatment; intravenous dantrolene given immediately to reduce pyrexia and muscle rigidity. Other supportive measures, such as rehydration, cooling and treatment of cardiac arrhythmias and failure are important. Glucocorticoids should be given where thyroid crisis is diagnosed as there is evidence of reduced adrenocortical reserve; they also inhibit hormone release and impair peripheral conversion of T_4 to T_3 .⁵ Antithyroid agents should be given orally.

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CASE REPORT

Open-heart surgery in a patient with a high oxygen affinity haemoglobin variant

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Summary

A man in heart failure with a high oxygen affinity haemoglobin variant (Hb Rainier) underwent a mitral commissurotomy with the aid of cardiopulmonary bypass. Pre-operatively, a total blood exchange transfusion was carried out to prevent potential hypoxic and thrombo-embolic complications. No complications occurred in the postoperative period.

Key words

Blood; haemoglobin.

Surgery; cardiovascular.

The anaesthetic management of patients with sickle cell disease is well documented.^{1–3} However, this is not the case in patients with a high oxygen affinity haemoglobin variant. A leftward shift of the oxygen dissociation curve (ODC) results in the presence of such a variant.⁴ As a result, oxygen uptake ($\dot{V}O_2$) is impeded. According to the Fick equation, $\dot{V}O_2$ is a function of three independent variables, haemoglobin concentration, blood flow and arterio-venous (A–V) oxygen content difference. A marked decrease in the latter theoretically results from a leftward shift of the ODC. Consequently, three physiological adjustments can occur. These are, an increase of haemoglobin concentration, of blood flow (particularly the cardiac output), and of the A–V oxygen content difference. Erythrocytosis has been largely shown to be the primary mode of compensation. The increase in the red cell mass can lead to high blood viscosity and to the possibility of vaso-occlusion. Conflicting data have been obtained concerning the cardiac output and the A–V oxygen content difference.⁴ In the present study, we report on the anaesthetic management of a patient with a high affinity haemoglobin variant, Hb Rainier (β 145 [HC2] Tyr → Cys) undergoing a commissurotomy for a mitral stenosis.

Case history

A 30-year-old man, who weighed 62 kg, was admitted for mitral valve replacement. His past medical history included

an episode of 'rheumatic' arthritis at 8 years of age. Several episodes of thrombophlebitis of the lower limbs occurred 2 months before his admission and finally he developed an acute arterial obliteration of the left leg. The patient was scheduled for surgery because of his mitral stenosis after partial amputation. Erythrocytosis was discovered: RBC, 6.07×10^{12} /litre; Hb, 18.4 g/dlitre and haematocrit, 56%. Red cell mass measurements were performed using ^{51}Cr -labelled red cells. Plasma volume was calculated from red cell mass and venous haematocrit. Theoretical total blood volume and red cell mass were estimated for a body surface area of 1.68 sq m. The ratios of red cell mass/theoretical red cell mass and total blood volume/theoretical blood volume were respectively 1.80 and 1.53 (as compared with 1.00–1.20 in normal controls). The ODC (Hem-O-Scan, Amino, Silver Spring, MD, USA) showed a leftward shift, $P_{50} = 12.5$ mmHg and Hill coefficient $n = 2.65$ as compared with 27.2 (SD) 1.57 mmHg and 2.69 (SD) 0.11, respectively in 15 controls (Fig. 1). Intra-erythrocyte 2,3-diphosphoglycerate (DPG) was found repeatedly to be increased in three different samples, 19.88, 19.34, and 20.4 $\mu\text{mol/g}$ Hb as compared with 12.83 (SD) 1.90 $\mu\text{mol/g}$ Hb in 15 controls. Blood coagulation parameters were found to be within the normal range. Cardiac catheterisation was carried out 15 days before surgery. The physiological parameters and determinants of oxygen transport were measured *in vivo*. Most of them were normal, including the cardiac index of 3.39 litres/minute/sq m, the A–V oxygen content difference of 4.4

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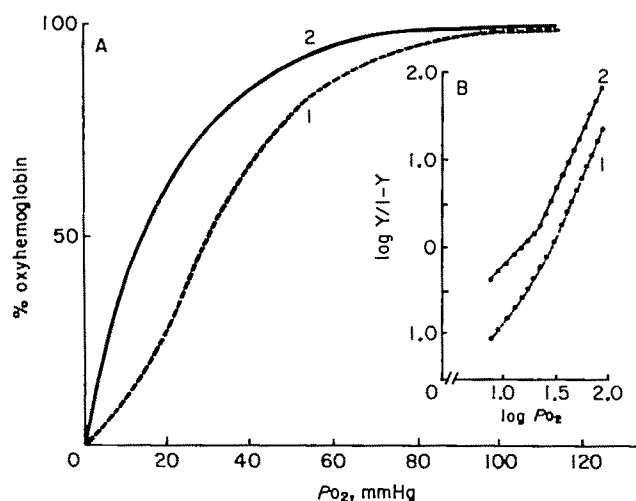


Fig. 1. Oxygen equilibrium curves measured on the whole blood. A: 1, normal control; 2, patient with Hb Rainier. B (inset): Hill plots, 1, normal control; 2, patient; Y: oxyhaemoglobin fraction.

ml/dlitre blood, the oxygen delivery \dot{D}_{O_2} ; 675 ml/minute/sq m and the oxygen uptake \dot{V}_{O_2} , 150 ml/minute/sq m. Only the mixed venous O_2 tension ($P\bar{V}O_2$) was reduced to 28.9 mmHg. Iso-electric focusing and polyacrylamide gel electrophoresis of globin chains were normal.⁵ Citrate agar electrophoresis (pH = 6.10) revealed an abnormal band slightly more anodical than Hb A. The increase in the alkali-resistance of total haemolysate (11.08%) strongly suggested the presence of Hb Rainier ($\beta 145 [HC2] \text{ Tyr} \rightarrow \text{Cys}$),⁶ which was confirmed by a structural study on a blood sample from a brother, who also carried Hb Rainier.⁷ The estimation of its percentage was more difficult. A previous report on Hb Rainier⁶ evaluated it about 25–34% of total haemoglobin. The variant displayed a normal stability. It was decided to exchange the total blood mass of the patient 12 hours before surgery because of the presence of heart failure. In addition, a clot developed in the left atrium. The blood exchange (1.5 of the total blood mass) was performed using a Haemonetics H-30 apparatus.

Operative management

The patient was orally premedicated with diazepam 20 mg and morphine 7 mg, intramuscularly. Monitoring was performed with an ECG after premedication; a radial artery cannula and a thermodilution pulmonary artery catheter were placed in the internal jugular vein (after unsuccessful insertion attempts in the pulmonary artery). Anaesthesia was induced with fentanyl 50 $\mu\text{g/kg}$ and thiopentone 5 mg/kg while breathing 100% oxygen. Pancuronium 0.1 mg/kg was used to induce paralysis and after tracheal intubation, ventilation ($F_{I_{O_2}} = 1$) was controlled. Heparin 250 mg was administered intravenously before cardiopulmonary bypass (CPB); this was performed under normothermic conditions. No haemodynamic instability occurred during this first period. A mitral commissurotomy and a left atrial thrombectomy were performed simultaneously. It took 43 minutes to perform CPB, and 40 minutes for aorta cross clamping. The patient required a total of 350 mg heparin. No protamine was used at the end of the operation and the patient made an uneventful postoperative recovery. No haemodynamic, haemorrhagic, thrombotic or pulmonary

complications were observed. The patient was discharged from the Department of Anaesthesiology 5 days after surgery.

Discussion

The presence of a high affinity haemoglobin variant has several consequences. The first to be seen is a marked decrease of the A–V oxygen content difference consequent upon the leftward shift of the ODC. The primary adjustment, in order to maintain a normal value of this parameter, is a decrease of $P\bar{V}O_2$. This has been experimentally demonstrated in animals after an acute leftward shift of the ODC.^{8,9} The second is the main adaptation of an increase in haemoglobin concentration. This adaptation occurs after a longer period and appears mediated by erythropoietin. It can induce an increase in blood viscosity and peripheral vascular resistance. The third is based on conflicting data from reports about other adaptative factors. Thus the $P\bar{V}O_2$ may be reduced or normal according to the haemoglobin variant.⁴ Cardiac output may be slightly increased or normal,⁴ and 2,3-DPG levels are generally normal. The presence of a high affinity variant may be compared to high altitude exposure, in which a decrease of $P\bar{V}O_2$, of erythrocyte 2,3-DPG, of haemoglobin concentration and cardiac output have been observed.^{10,11} The latter occurs only a few days after the start of exposure to altitude.

In the present case, there was a reduction of $P\bar{V}O_2$, the cardiac output was normal and the erythrocyte 2,3-DPG was repeatedly increased. The reason for this increase remains unexplained. This latter causes a slight decrease of the blood oxygen affinity.⁴ The 2,3-DPG effect on the ODC is opposed by the large leftward shift produced by the presence of the high affinity haemoglobin variant.

In patients with a high affinity haemoglobin variant, hypoxia is admittedly mild, compared with situations in which blood lactate is increased e.g. anaerobic metabolism. Blood lactate was normal in the present case. Nevertheless, acute hypoxic complications constitute, at least theoretically, a potential threat. Another potential risk for these patients is represented by thrombo-embolic complications. The presence of mitral stenosis and arrhythmias could amplify this risk. Pre-operative blood exchange transfusion presents two advantages. It markedly improves \dot{V}_{O_2} by shifting the ODC towards the right, and it decreases the thrombotic risk. The potential depletion of 2,3-DPG in transfused whole blood was resolved by the use of fresh blood (one day old). Haemodilution, is an alternative pre-operative measure. It decreases blood viscosity, improves blood flow and facilitates heart work and no blood transfusion is required.

In conclusion, we lack information concerning the value and limits of blood exchange transfusion before major surgery in patients with a high affinity variant. The present case report is intended to provide some information in this respect.

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CASE REPORT

Impairment of the antagonism of vecuronium-induced paralysis and intra-operative disopyramide administration

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Summary

A 63-year-old male was admitted to hospital for a cholecystectomy, vagotomy and gastro-enterostomy. Muscle paralysis was induced with 70 µg/kg vecuronium, followed by increments of 20 µg/kg when the initial twitch height returned to 25% of control. The patient received 3 doses of 10 mg disopyramide intravenously, on account of supraventricular ectopic beats, followed by an infusion of 25 mg/hour. Paralysis was reversed using 0.75 mg atropine and 2.5 mg neostigmine once the twitch height had returned spontaneously to 25% of its initial value. Fifteen minutes later, twitch height had returned to control value and the train-of-four was above 85%, but the responses to tetanic stimulation at 100 Hz and 50 Hz remained severely depressed (10% and 45%, respectively). The patient's trachea was extubated after 20 minutes, but residual fade was still observed. This impairment of neuromuscular transmission, detected only with high frequency stimulation, was present with a measured concomitant plasma level of disopyramide of 5.1 µg/ml.

Key words

Neuromuscular relaxants; vecuronium.

Pharmacology; disopyramide.

Many anti-arrhythmic drugs, including disopyramide, interfere with neuromuscular transmission.^{1–3} However, clinical reports of interactions that result from the combined use of anti-arrhythmic drugs and non-depolarising muscle relaxants are not well documented.^{4,5} This case report illustrates delayed reversal of vecuronium-induced paralysis in a patient receiving disopyramide.^{6–10}

Case history

A 63-year-old male (69 kg, 165 cm) was admitted to hospital for cholecystectomy, gastro-enterostomy and vagotomy. For one month he had complained of pain in the right hypochondrium, nausea and biliary vomiting; biliary stones were seen on X ray and confirmed by echographic studies. There was a history of recurrent gastric ulcers, which were treated by cimetidine. Three years previously the patient had undergone three vessel coronary artery bypass grafting. There was a previous history of myocardial infarction and a right nephrectomy had been performed 13 years ago. Pre-operative daily medication consisted of disopyramide 250 mg twice daily, dipyridamole 75 mg twice daily and dinitrate isosorbide 30 mg twice daily. The patient appeared in good physical status on examination; the head, neck, lungs and heart were normal.

Systemic blood pressure was 135/85 mmHg, and heart rate 80 beats/minute. An electrocardiogram (12 leads) demonstrated normal sinus rhythm and a left anterior hemi bundle block. Chest X ray revealed the ligatures of a previous sternotomy but was otherwise normal. A barium-enema examination demonstrated stenosis of the superior duodenum that resulted from a chronic ulcer. Blood chemistry was within normal limits except for creatinine at 1.9 mg/100 ml, bilirubin at 1.8 mg/100 ml and alkaline phosphatases at 300 IU/litre.

One hour before anaesthesia, the patient received 10 mg diazepam and 400 mg cimetidine by mouth. Anaesthesia was induced with etomidate 0.3 mg/kg, droperidol 0.07 mg/kg, fentanyl 8.5 µg/kg administered through a 5% dextrose infusion. Ventilation of the lungs was controlled manually (semi-open system, 50% oxygen in nitrous oxide) after the onset of unconsciousness until intubation of the trachea. A force displacement transducer (UC3 cell Statham), fitted with tension attenuator (UL4-20-Statham) and incorporated in a hand grip, was secured with adhesive tape to the left hand of the patient in order to measure the isometric contraction of the *adductor pollicis*. Stimulation of the ulnar nerve was by square-wave pulses of 0.2 msec duration, and supramaximal intensity delivered at 0.1 Hz from a grass S88 stimulator through two 25-gauge thin-

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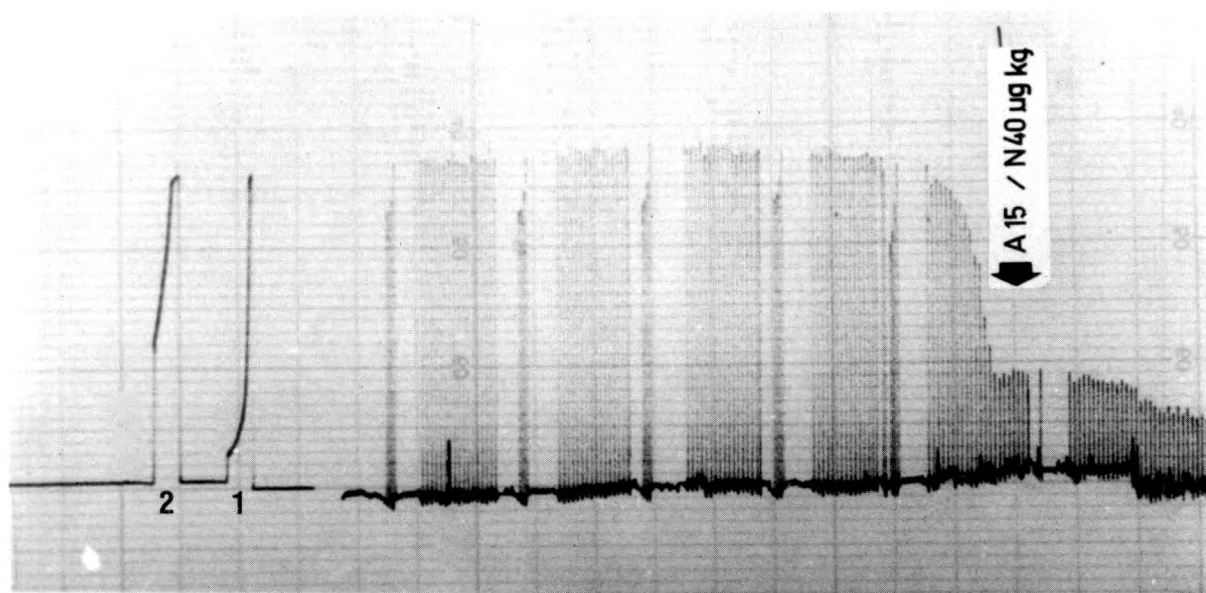


Fig. 1. The recovery of the twitch height, train of four, and tetanic, 100 Hz (1) and 50 Hz (2), responses were recorded from *adductor pollicis* muscle after reversal of the vecuronium neuromuscular blockade with intravenous neostigmine 40 $\mu\text{g}/\text{kg}$ (N40) and atropine 15 $\mu\text{g}/\text{kg}$ (A15).

walled needles placed subcutaneously. The resulting analogue signals were amplified and registered on a polygraph recorder. An intravenous bolus injection of 70 $\mu\text{g}/\text{kg}$ vecuronium was administered when a stable twitch height was achieved. Tracheal intubation was performed when the twitch height decreased to 5% of its initial value and thereafter ventilation was controlled mechanically (semi-closed system, 50% oxygen in nitrous oxide) until the end of the surgical procedure. Ventilation was adjusted to produce normocapnia (end-tidal carbon dioxide, $5.0 \pm 0.1\%$), as measured with a Datascope 500 TM carbon dioxide analyser. Additional doses of fentanyl were given when clinical signs of inadequate analgesia were observed. Heat loss from the body core and from the exposed arm was decreased by the use of a warming mattress (rectal temperature, 37°) and surgical sheets.

The patient received metronidazole 500 mg, and cefuroxime 1.5 g both administered intravenously 15 minutes after induction of anaesthesia. Thirty minutes after induction, the ECG showed a left bundle block and atrial extrasystoles which were successfully treated with three doses of 10 mg intravenous disopyramide followed by an infusion of 25 mg/hour. The systolic blood pressure remained between 80 and 120 mmHg during the whole surgical procedure. Intra-operative sodium and potassium plasma concentrations were within normal limits (133 and 136 mmol/litre and 3.54 and 3.94 mmol/litre respectively).

The surgical procedure was completed after 2.5 hours and the intra-operative blood loss was about 300 ml. The patient had received 20 $\mu\text{g}/\text{kg}$ of vecuronium each time the twitch height returned to 25% of its initial value; the mean time between vecuronium doses was 25 minutes and no accumulation was seen. Residual paralysis was antagonised at the end of surgery with atropine 0.75 mg and neostigmine 2.5 mg when the twitch height was 25% of control. After 3 minutes, the twitch height was 91% of control and the train-of-four 75%. At the fifteenth minute, twitch height was 100% and train-of-four 85%. However, despite adequate recovery of twitch height and the train-of-four, tetanic

stimulation at 100 Hz and 50 Hz remained markedly depressed (10% and 45%, respectively) (Fig. 1).

The venous plasma samples taken immediately after tetanic stimulation showed normal Na^+ and K^+ values. Disopyramide plasma concentration, determined by an enzyme immuno-assay method (Emit-cad disopyramide assay), was 5.1 $\mu\text{g}/\text{ml}$.^{11,12} The patient's trachea was extubated, after a delay of 20 minutes, because the tidal volume was normal and breathing appeared adequate. Slight residual fade was observed in both head lift and hand-grip tests, after the patient became conscious and cooperative. This fade remained present for about one hour postoperatively but had no influence upon the immediate postoperative course of the patient.

The indirectly elicited *adductor pollicis* muscle responses of this patient were compared with a series of patients ($n = 6$) who received no disopyramide; monitored and anaesthetised as described previously.¹³ These control patients received a methohexitone (1 mg/kg), fentanyl, N_2O and O_2 anaesthetic sequence. They were kept under normocapnic and normothermic conditions. Monitoring of neuromuscular transmission was undertaken in exactly the same manner in these control patients as that described in this case report. The control patients also received a vecuronium loading dose of 100 $\mu\text{g}/\text{kg}$, followed by 20 $\mu\text{g}/\text{kg}$ each time the prereversal twitch height regained 25% of the baseline reading. The train-of-four results and the responses to the tetanic stimulations are presented in Figure 2.

Discussion

The electrophysiological effects of disopyramide on heart cells^{3,6-10,14} are similar to those induced by quinidine.^{1,4} This agent has a local anaesthetic effect which reduces the mobilisation of acetylcholine. Besides a similar presynaptic mode of action, disopyramide also possesses some anticholinergic activity at nicotinic receptor sites. Both pre- and postsynaptic modes of action may explain the decrease of neuromuscular transmission observed *in vitro* using the rat

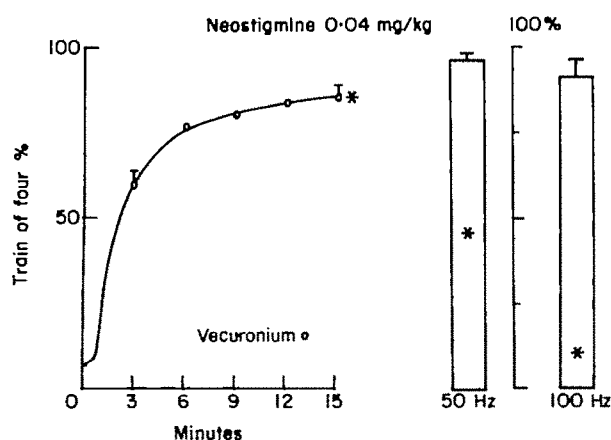


Fig. 2. Evolution of the train of four and tetanic (50 Hz and 100 Hz) responses after reversal of vecuronium paralysis with intravenous neostigmine: 40 µg/kg, and atropine: 15 µg/kg, in normal patients ($n = 6$). These data are drawn from reference 13 *, the abnormal values observed in the present patient.

phrenic nerve hemidiaphragm preparation² [disopyramide bath concentrations of 5.6×10^{-6} mol/litre (or 17.85 µg/ml) and nerve stimulation frequency of 0.2 Hz]. Potentiation of the effects of tubocurarine and decreased antagonism of neostigmine were also demonstrated in the same preparation.

More recently, Jones and Marshall³ have demonstrated noncompetitive effects of disopyramide upon the chick biventer cervicis preparation at concentrations that ranged from 5.10^{-5} to 10^{-3} mol/litre. They concluded, because of the voltage-dependent nature of the block and the weak antagonist action of anticholinesterase agents, that endplate ion channel block may be the main mechanism of action of disopyramide in this preparation.

This case report suggests that therapeutic disopyramide blood concentrations, of 5 µg/ml, may impede normal antagonism of vecuronium paralysis using neostigmine given in the normal dosage (about 40 µg/kg). The influence of disopyramide on neuromuscular transmission appears only detectable at high frequencies of stimulation, as reflected by the marked 50 and 100 Hz tetanic fade observed in the present patient. Monitoring of the degree of paralysis present should be undertaken if disopyramide is used in the presence of muscle relaxants.

Neuromuscular transmission may also be depressed by other drugs that possess pre- and/or postsynaptic effects, antibiotics or halogenated vapours¹⁵ for example. Anaesthesia was free from halogenated vapours in the present case report but the patient had received metronidazole (7.5 mg/kg) and cefuroxime (22 mg/kg) shortly after arrival in the operating room. Despite recent evidence of the lack of potentiation of vecuronium-induced paralysis by metronidazole in usual doses,¹⁶ a more complex interac-

tion between metronidazole, disopyramide and vecuronium cannot be entirely ruled out in this case.

To conclude, this case suggests that patients treated with disopyramide may exhibit abnormal patterns of paralysis antagonism. Sustained residual tetanic fade at 100 Hz (10%) and at 50 Hz (45%) has been observed despite normal recovery of twitch height and train-of-four. This observation also suggests that train-of-four recovery above 75% is not necessarily sufficient in all clinical circumstances to show that the function of the neuromuscular junction has returned to normal.

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Automatic control of arterial pressure after cardiac surgery

Evaluation of a microcomputer-based control system using glyceryl trinitrate and sodium nitroprusside

J. R. COLVIN AND G. N. C. KENNY

Summary

Arterial hypertension after cardiac surgery is common and is associated with increased morbidity. Glyceryl trinitrate may be a more suitable agent for control of hypertension than sodium nitroprusside. We have developed a closed-loop system for the Atari 1040ST microcomputer to control arterial pressure by the simultaneous infusion of two vasodilators under computer control. Use of this system with glyceryl trinitrate and sodium nitroprusside in 24 patients who required vasodilators after cardiopulmonary bypass, revealed that hypertension was controlled by glyceryl trinitrate alone in 14 of the patients and 10 required supplementary sodium nitroprusside. The results suggest that glyceryl trinitrate is a suitable agent for control of hypertension after cardiac surgery in the majority of patients. They also show that a sizeable minority required additional sodium nitroprusside, and that an automated 'dual pump' system is a satisfactory method of administering two vasodilators in this way.

Key words

Blood pressure; hypertension.

Computers; control.

Hypertension occurs frequently within 4–6 hours of cardiopulmonary bypass, despite adequate sedation and controlled ventilation,^{1,2} and is associated with increased systemic vascular resistance. This vasoconstriction is accompanied by increased sympatho-adrenal activity and high levels of circulating catecholamines, which result from the stress response to anaesthesia, surgery and cardiopulmonary bypass.³ Reflex vasoconstriction, in response to a reduction in core temperature after bypass, and activation of the renin-angiotensin system are other factors that have been implicated.¹ The overall incidence of hypertension after cardiopulmonary bypass has been reported as 15–40%.⁴ This tends to be higher in patients who undergo myocardial revascularisation, in whom the incidence may be as high as 50%.⁵

This early postoperative hypertension is associated with increased morbidity caused by postoperative blood loss and risk to suture lines.^{5,6} It may also have a detrimental effect on myocardial oxygen balance.⁷ The usual management of this hypertension is by infusion of short acting vasodilators, most commonly sodium nitroprusside (SNP). Kaplan and others have suggested that glyceryl trinitrate (GTN) may be a more suitable antihypertensive agent in these patients.^{8,9} Glyceryl trinitrate may have advantages over SNP in terms of effects on the cardiovascular system, and because it has no direct toxic consequences.

The effect of these agents on myocardial oxygen balance immediately after myocardial revascularisation is unclear,

but while SNP may worsen oxygen balance and cause coronary 'steal' in patients with ischaemic heart disease,^{10,11} GTN has been shown to improve oxygen balance in such cases.^{10,12} There is controversy about how these agents work on the pulmonary circulation. Some authors have suggested that GTN has a more beneficial effect on intrapulmonary shunt than SNP,^{9,13} while others have detected no significant change in shunt with either GTN or SNP.^{14,15}

The toxic metabolic effects of SNP caused by cyanide-related metabolites are well documented.^{16,17} Various 'safe' upper dose limits are recommended, based either on a maximum infusion rate (6–8 µg/kg/min),¹⁸ or on a maximum total dose (1.5 mg/kg).¹⁹ Earlier preparations of GTN were implicated as a cause of methaemoglobinaemia and some currently available preparations are associated with toxic effects because of their alcohol and high potassium contents.^{20–22} However, no direct toxic effects are reported from the use of commercial aqueous preparations.

To assess further the role of GTN in this context, we have developed a closed-loop arterial pressure control system based on the Atari 1040ST microcomputer. Several studies that compared automatic with manual control of arterial pressure have shown superiority of automatic control.^{23–25} In addition, a microcomputer-based system can store cardiovascular and infusion information at frequent intervals; this allows detailed and unbiased assessment of the therapy. A diagrammatic representation of the system is shown in Figure 1.

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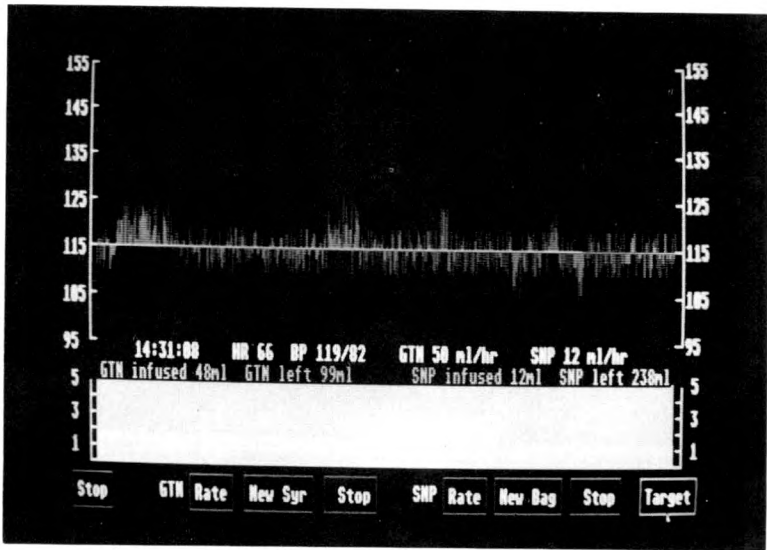


Fig. 2. Screen view of Atari during closed-loop blood pressure control with GTN and SNP.

Methods

Development of system

The efficacy of GTN in the management of hypertension after cardiac surgery is not established clearly and preliminary studies showed that an automatic blood pressure controller that uses GTN alone might prove inadequate. To overcome this potential difficulty, our Atari-based system was developed to control two vasodilator infusions simultaneously. This closed-loop systolic arterial pressure control system was developed from that described by Reid and Kenny.²⁵ The program is considered conveniently in terms of its four component parts.

Data collection and verification. Cardiovascular information is collected directly, in analogue form, from the intra-arterial blood pressure monitor. The system detects, rejects and activates an audiovisual warning of the following abnormal waveforms: loss of pressure caused by arterial line disconnection or zeroing of transducer; a large constant change in pressure, as occurs on flushing or sampling from the line; abnormal waveform caused by artifact such as disturbance of the manometer tubing.

Cardiovascular data are used for frequent recalculation of infusion rate and, together with infusion information,

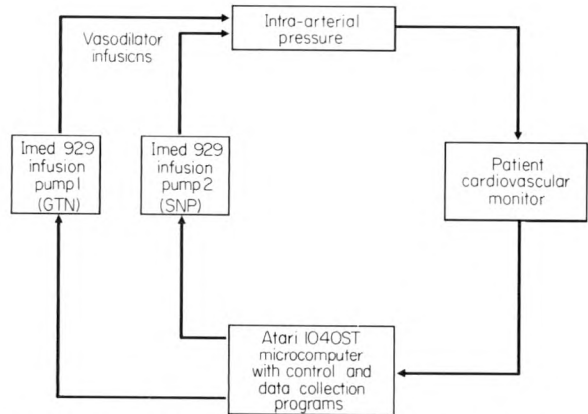


Fig. 1. Diagram of the dual-pump closed-loop control system based on the Atari 1040ST microcomputer.

are stored to disc and displayed on the colour visual display unit in the form of trend graphs and numerical information (Fig. 2).

Communication with infusion pumps. The system controls two Imed 929 volumetric pumps using a subroutine written in BASIC. These infusion pumps are designed specifically for computer control applications though they may be used conventionally, under manual control, if required. Each pump is wired with its own specific address for independent communication. Two-way communication between the Atari and each pump must occur frequently (every 22 seconds), or audio visual alarms are activated both by the pump and the computer. We consider this safety feature essential in an automatic control system for clinical application.

Control algorithm. The control algorithm is based on a proportional-integral-derivative controller, described originally by Sheppard,²⁶ and developed for use with a microcomputer by Reid and Kenny.²⁵ The system is set to allow closed-loop infusion of GTN (Nitrocline, Schwarz Pharmaceuticals), up to a preset maximum infusion rate of 50 mg/hour, then automatic addition of SNP by the second computer-controlled infusion if further reduction in arterial pressure is required. The control system is based on our current practice, which is to control systolic pressure, and because the systolic pressure may be a more clinically appropriate index of myocardial work.

User-computer interface. The user interface must be easy to operate, and should be designed to minimise the possibility of entering erroneous instructions or information. Our system utilises a 'mouse' controlled screen arrow to select options from a series of labelled boxes and 'windows'. This obviates the need for keyboard skills in the clinical staff and also provides a degree of inbuilt safety in that only 'sensible' options are included in the option selection menus.

Evaluation

Evaluation of this dual-pump closed-loop control system was carried out in 24 patients who required therapeutic intervention to control hypertension after elective cardiac surgery. All patients gave informed consent. All had comparable midazolam/opioid/relaxant anaesthetic technique,

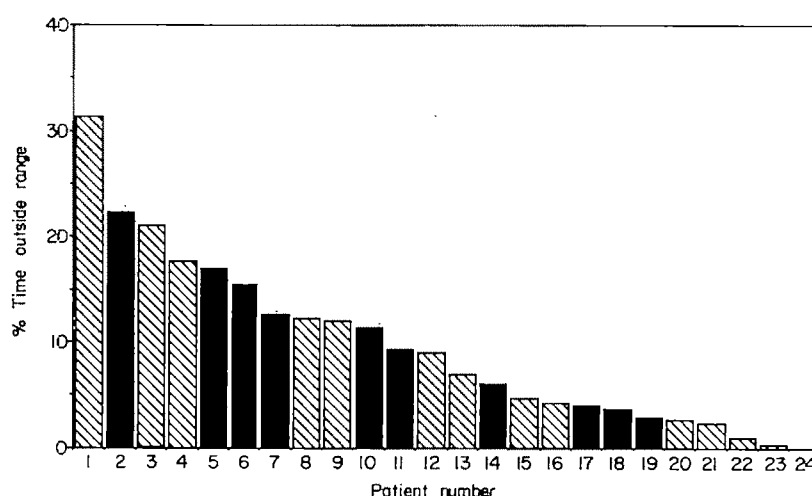


Fig. 3. Quality of control achieved in each patient.

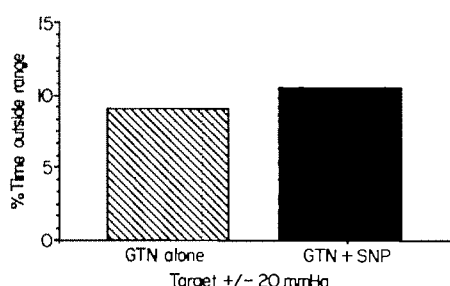


Fig. 4. Comparison of mean quality of control between the groups.

and all had elective artificial ventilation of the lungs continued postoperatively. Intravenous bolus doses of morphine and midazolam were used for sedation in the immediate postoperative period. Frequent monitoring of arterial blood gases was carried out to ensure adequate ventilation.

The target systolic pressure was set as the midpoint of a range prescribed by the surgical staff. The patients were studied for the first 5 hours of the postoperative period, though the closed-loop therapy was continued for longer if required. The quality of arterial pressure control in each patient was assessed in terms of the percentage time spent outside a range of target pressure ± 20 mmHg. In addition, patients were subdivided into those controlled by GTN alone, and those who required supplementation with SNP. This retrospective allocation was carried out for four reasons. Firstly, to make some preliminary assessment of the relative numbers in each group; secondly, to compare the quality of control achieved between the two groups; thirdly, to determine if a plateau effect of response to increasing doses of GTN occurred; and fourthly, to compare several variables between the two groups to see if any predictive factors emerged.

Results

Of the 24 patients studied, 16 underwent myocardial revascularisation and eight had valve replacement surgery. Assessment of the quality of control achieved in each patient is shown in Figure 3. Time spent outside the assessment range varied from 31.3 to 0% of the 5-hour study period, with a mean of 9.56%.

Table 1. Demographic data of the two groups. No significant differences were found.

	GTN group	GTN + SNP group
Mean age (SEM)	57.6 (2.5)	58.1 (3.3)
Mean weight (SEM)	68.5 (5.8)	74.8 (2.7)
Males/females	8/6	7/3

Table 2. Systolic arterial pressures of the two groups. No significant differences were found.

Systolic pressure (mmHg)	GTN group	GTN + SNP group
Pre-operative median (range)	140 (110–160)	135 (120–180)
Starting median (range)	131 (110–150)	133 (115–155)
Target median (range)	120 (110–125)	120 (110–125)

Analysis of the results revealed that in 14 of the patients arterial pressure control was achieved with GTN alone, while 10 required the addition of SNP. The distribution of each group for the percentage time spent outside the range is similar, as seen in Figure 3. Comparison of the control data between each group using a two-tailed Mann-Whitney *U* test, revealed no significant difference in quality of control between the group controlled by GTN alone and the group who required a combination of GTN and SNP. The mean value for each group is shown in Figure 4.

Further analysis of the 14 patients controlled by GTN alone was carried out to determine the proportion of time spent in each 5 mg/hour infusion rate band. The outcome of this analysis is expressed in Figure 5, which shows the results as a percentage of the total time for all the GTN group of patients over the 5-hour study period. This reveals that 96% of the total time for all the GTN group of patients was spent at infusion rates of less than 25 mg/hour.

Demographic information for each group is shown in Table 1, while Tables 2 and 3 show the results of retrospective analysis of some other factors which may have

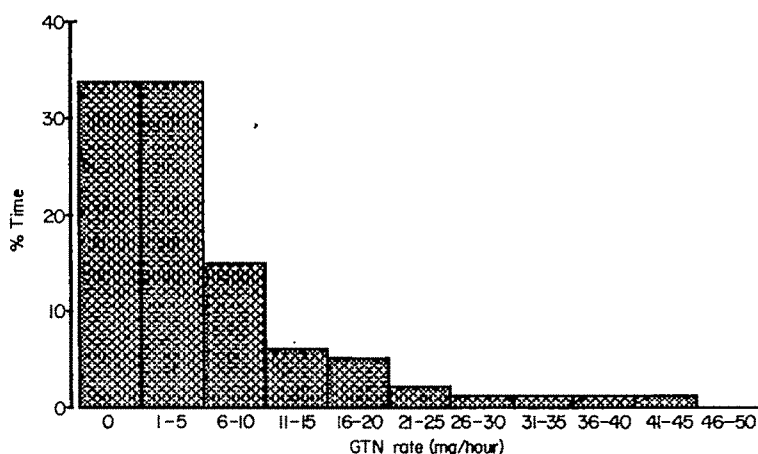


Fig. 5. Amount of time spent at each infusion rate band for the group controlled by GTN alone.

Table 3. Operation, bypass time and lowest temperature in each group. No significant differences were found.

	GTN group	GTN + SNP group
Myocardial revascularisation/valve	9/5	7/3
Bypass time (minutes) median (range)	91.5 (36-161)	97.5 (30-129)
Lowest temperature (°C) median (range)	28 (25-32)	28 (25-28)

determined whether a patient was controlled by GTN alone or also required SNP. There were no significant differences between the groups in terms of age, sex, weight, operation, bypass time and temperature, pre-operative, starting and target systolic arterial pressures.

Discussion

Implementation of this automatic arterial pressure control system in the cardiac intensive care unit was readily acceptable to the nursing staff, as many had previous experience of closed-loop blood pressure control.²⁷ A survey of nurse opinion, within the unit revealed that, with only a short instructional session on the use of the Atari-based system and control of the program with the 'mouse', all found the system convenient and simple to use. The screen display of cardiovascular and infusion information allowed rapid appreciation of cardiovascular trends, and doses of vasodilators delivered. The system incorporates several features designed to maximise safety during clinical use. These include rigorous artefact detection and rejection functions in the data collection routine; the use of 'limited-option' menus for entering information with the 'mouse'; and the requirement for frequent two-way communication between the infusion pumps and the computer.

Analysis of arterial pressure control on an individual patient basis reveals that it was satisfactorily achieved in all the patients. The quality of control was similar to that reported by Reid and Kenny in a study which compared automatic with manual control by the nursing staff.²⁵ The fact that 14 of the patients were controlled by GTN alone and 10 required the combination of GTN and SNP, suggests that in the majority of hypertensive patients after cardiac surgery arterial pressure control can be achieved with GTN

alone. In addition, the quality of control between the two groups was not significantly different.

Fahmy found that doses up to 500 µg/minute could induce hypotension during anaesthesia without demonstrable toxic effect²⁸ and Kaplan and his colleagues reported that 53% of patients after cardiac surgery were controlled by GTN in doses up to 128 µg/minute.⁸ Preliminary work suggested that there may be a plateau effect seen with increasing doses of GTN, therefore 50 mg/hour (833 µg/minute) was chosen as the maximum infusion rate in our study to determine if any such plateau became apparent. Our results suggest that there may be a plateau of effect at doses in the region of 25-30 mg/hour, but further evaluation with a larger study population is required to confirm this.

No toxic effects were noted with the doses of GTN used in our study. We used the aqueous preparation, Nitrocline (Schwarz Pharmaceuticals), which is free from the alcohols and high potassium content that have been implicated as causes of the adverse effects associated with the use of intravenous GTN.²⁰⁻²² Nitrocline is presented as 50 ml of 1 mg/ml solution in a glass bottle, from which it can be infused directly using a nonadsorbent giving set (Imed Accuset 'Nitro', Imed Corp., San Diego). This obviates the need for transfer or dilution, with the attendant risks of error or contamination. This also circumvents the problem of GTN adsorption onto plastic containers made from polyvinyl chloride.

Retrospective analysis and comparison of demographic data and other factors between those patients controlled by GTN alone and those who also required SNP, revealed no significant differences. This allocation of patients into the GTN or GTN plus SNP combination therapy groups is to some extent arbitrary, in that the numbers in each group will depend on the preset upper dose limit for GTN. Our results suggest that if the maximum GTN dose had been set at 25 mg/hour there would have been 10 patients in the GTN only group, with 14 requiring additional SNP.

The role of GTN as an antihypertensive agent after cardiopulmonary bypass is not defined clearly. The putative advantages of GTN over SNP in these patients in terms of effects on the coronary and pulmonary circulations have yet to be demonstrated clearly. There can be little doubt, however, of the safety of GTN relative to SNP in terms of systemic toxicity at the high infusion rates that are often

required in these patients. This study shows that preferential use of GTN meant that SNP was avoided in 14 of the 24 patients who required therapeutic control of arterial pressure. Whether or not the use of GTN reduces the SNP requirements in the patients who need the GTN plus SNP combination therapy could be determined readily by a direct comparative study with a group who received only SNP.

Conclusion

This study demonstrates that closed-loop GTN can provide satisfactory arterial pressure control in the majority of hypertensive patients after cardiac surgery. However, because of the sizeable minority who also require SNP, we suggest that if GTN is to be used in this context, the option to add SNP should be readily available. Our dual-pump automatic control system fulfils these criteria and has been shown to function satisfactorily and safely in the clinical environment. In addition, this system provides a data collection facility to allow detailed and unbiased assessment of the closed-loop therapy. It may also be used in a similar manner to evaluate other short acting vasodilators, and is currently in use with GTN and SNP to assess further the effects of these agents on the pulmonary circulation.

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Anaesthetic management of the patient with a permanent pacemaker

P. BLOOMFIELD AND G. M. R. BOWLER

Summary

Over 25 000 people in Britain now have pacemakers, and the number is increasing steadily. Anaesthetists encounter patients with pacemakers regularly. Knowledge about the increasingly wide range of pacemakers available is necessary to ensure safe management of these patients, many of whom are frail and elderly. This review outlines the indications for permanent pacing, the types of pacemaker used and the assessment and management of pacemaker patients for anaesthesia.

Key words

Heart; arrhythmias, pacemaker.

Principal indications for permanent pacing^{1,2}

Sick sinus syndrome

Sick sinus syndrome is the commonest indication for permanent pacemaker implantation and is characterised by sinus arrest, sino-atrial block, severe bradycardia, or episodes of alternating tachycardia and profound bradycardia. Bradycardia, or occasionally tachycardia, may cause dizziness or syncope. This condition occurs in all ages but is more common in the elderly and is not associated usually with other heart disease.

Atrioventricular block

Disease of the conducting system of the heart develops commonly in the absence of associated heart disease.

First degree atrioventricular block is characterised by prolongation of the PR interval beyond 0.20 seconds, is benign and does not require pacing.

Second degree atrioventricular block occurs when a single atrial impulse that should be conducted to the ventricles fails to do so. Type I (Wenckebach) is characterised by progressive lengthening of the PR interval which culminates in a P wave that is not conducted. This condition was considered previously to be benign but is now recognised as an indication for a permanent pacemaker, because mortality is increased in unpaced patients.³ In Type II second degree atrioventricular block the PR interval of conducted beats is constant and the QRS complex is usually broadened; progression to complete heart block occurs frequently and the presence of Type II block is an indication for a permanent pacemaker.

Third degree or complete heart block invariably requires permanent pacing unless it is congenital in origin.

Bifascicular block

This describes the appearance on the electrocardiogram (ECG) of right bundle branch block with marked left or right axis deviation. A small minority of patients may develop transient or established complete heart block and require implantation of a permanent pacemaker. The risk of progression to complete heart block in asymptomatic patients is very small, and such patients do not require a permanent pacemaker; it is not necessary to insert a temporary pacemaker during general anaesthesia.⁴

After myocardial infarction

The conducting system may be damaged by myocardial infarction but usually recovers. Occasionally, a permanent pacemaker is indicated if heart block persists or if bifascicular block has progressed transiently to complete heart block, with subsequent recovery. Patients who develop conduction defects after an anterior myocardial infarction have usually experienced extensive myocardial damage and have a poor prognosis, but this is not usually so after inferior infarction.

Types of permanent pacemaker and their recognition¹

The most widely used types of permanent pacemaker utilise a lead implanted in the right ventricle and pace the heart

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Table 1. Three letter code of pacing modes and functions.

1st: Chamber paced 2nd: Chamber sensed 3rd: Mode of response		
V, ventricle	V, ventricle	T, triggered
A, atrium	A, atrium	I, inhibited
D, double	D, double	D, double
	O, none	O, none

Table 2. Pre-operative assessment of the permanent pacemaker patient.

Coded information recorded at implantation on European Pacemaker Registration Card	Symptom	01-02 Unspecified 03-04 Dizziness or syncope 05 Bradycardia 06 Tachycardia 07-09 Miscellaneous conditions
	ECG	01-04 Sinus or unspecified
	Rhythm	05-07 Second degree AV block 08-10 Complete heart block 11-21 Bundle branch or bifascicular block
	Aetiology	01-03 Unspecified 04-05 Idiopathic or ischaemic 06 Postinfarction 07-11 Miscellaneous conditions
ECG rhythm		
1. All beats preceded by a pacemaker 'spike': assume patient is pacemaker-dependent.		
2. If native rhythm predominates patient is unlikely to be pacemaker-dependent.		
3. No evidence of pacemaker activity; magnet may be applied over pulse generator to switch to fixed rate pacing.		
4. If pacemaker spike is not followed by P or QRS wave suspect pacemaker malfunction. [N.B. If pacemaker is activated by a magnet to pace at a fixed rate, the spike may fall in the refractory period and fail to stimulate the ventricle (see Fig. 3).]		
Chest X ray		
1. Location of pulse generator.		
2. Location of leads in atrium, ventricle or both.		
3. If necessary pulse generator model can be identified.		

European Pacemaker Registration Card

1 Patient-Data

Identification Nr. 4903

Name Mr A J Smith

Address 21 East Street

City/Zip Anytown

Country Great Britain

Tel-Nr 031 227 7446

Date of birth 03.09.1921

Date of last implantation 17.03.1988

Symptom 03

ECG 212

Aetiology 07

2 Pacemaker Centre

Code-Nr.

Doctor/Department Dr A R Bruce

Hospital Royal Infirmary

Address Main Street

City/Zip/Country Anytown

Tel-Nr 031 227 9993

3 IPG

Rate 70 ppm

Mode VVI

PD 2.5 ms

Date of implantation 17.03.1988

MFG VITATRON

Type CERYX-3

Serial-Nr. 001967

4

Lead(s)

atrial

ventricular

Date of implantation 17.03.88

MFG CERYX

Type 327168 P

Serial-Nr. R 10576

unipolar/bipolar unipolar

endoelect. ENDO

European Pacemaker Registration Card

Fig. 1. European Pacemaker Registration Card. Details of symptoms, ECG findings and aetiology of the condition that necessitated implantation are given in code form in section 1; see Table 2 for explanation. Sections 3 and 4 give details of the pulse generator and lead.

only if no spontaneous ventricular depolarisation occurs. Some modern pacemakers may operate through a lead in the atrium, the ventricle or both. A sensed spontaneous depolarisation may be used either to inhibit the pacemaker or to trigger a paced impulse. Thus, a variety of different pacing modes is now available and each is described by a universally accepted three letter code (Table 1). In VVI pacing, the ventricle is paced and the pacemaker is inhibited if an intrinsic depolarisation is sensed. An AAI pacemaker paces the atrium and is inhibited by intrinsic atrial depolarisation. Pacemakers with leads in both the atrium and ventricle are more complex; for example with VAT pacing, ventricular pacing occurs when an impulse is sensed through the atrial lead and this triggers stimulation of the ventricle through the ventricular lead. Virtually all dual-chambered pacemaker systems are now implanted in DDD mode. This provides atrial pacing during atrial bradycardia and ventricular pacing after a spontaneous or paced atrial beat if a spontaneous ventricular beat is absent. In many pacemakers the mode of pacing and other settings of the pacemaker, e.g. pacing rate, may be changed after implantation, usually by radiofrequency transmission from a programming device placed over the pacemaker. Some

recent pacemakers pace only the ventricle but increase the pacing rate in response to increased bodily activity.⁵

All patients who have a permanent pacemaker implanted receive a registration card to identify the type of pacemaker, the pacing mode and pacing rate, and the responsible cardiologist at the time of implantation (Fig. 1). The symptoms, ECG findings and aetiology of the condition that necessitated pacemaker implantation are indicated by code numbers which are not explained on the card but are summarised for reference in Table 2. Details of any changes in programming after implantation are given on the reverse of the card but are not always updated by the cardiology department. A chest radiograph may be used to identify whether an atrial or ventricular lead or both are present (Fig. 2). An ECG recorded when the pacemaker is active identifies which chamber is being paced by the presence of a wave or a QRS complex after the pacemaker artefact spike. With dual chamber pacemakers, a spike may precede the P wave, the QRS complex or both, depending on the mode of operation (Fig. 3). The pacemaker may be inhibited by the patient's own rhythm when the ECG is recorded but can be changed to fixed rate pacing by applying a magnet over the pacemaker to reveal which chamber or chambers can be paced (Fig. 3). Not all pacemakers are programmed to pace at 70 beats/minute and a lower pacing rate is often chosen for patients with sick sinus syndrome so that the intrinsic heart rhythm is preserved unless profound bradycardia occurs.

Anaesthetic management

The following guidelines obviate the need to seek the advice of a cardiologist before anaesthesia, but if any doubt exists it is better to seek advice before surgery.

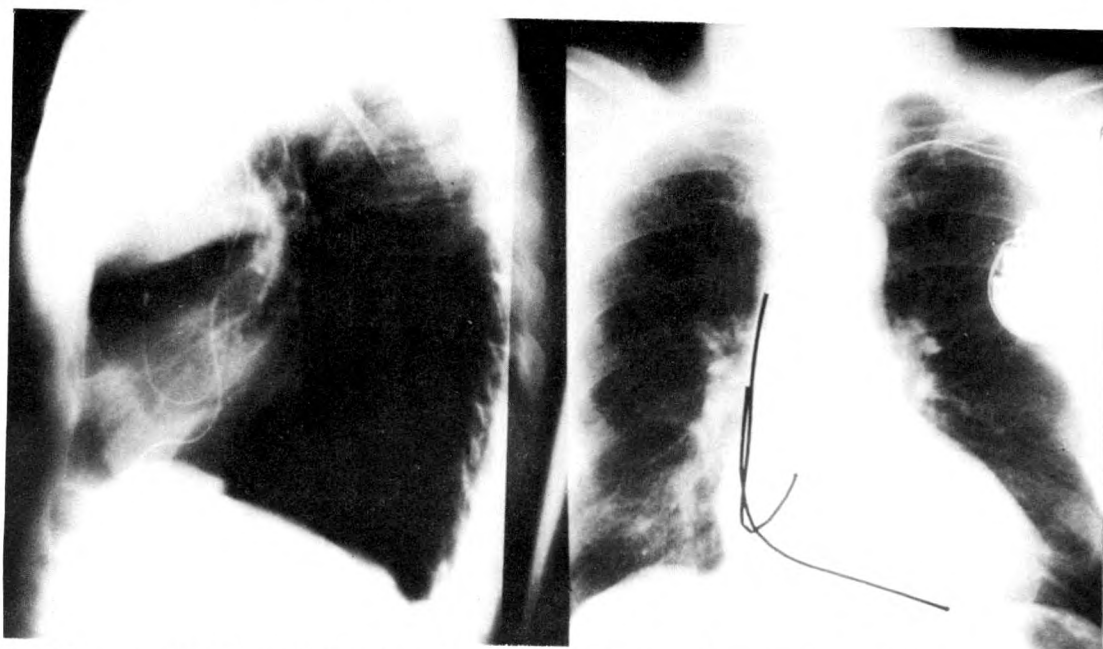


Fig. 2. Posteroanterior and lateral chest X rays of a patient with a dual chamber pacemaker. In the posteroanterior view, the atrial lead can be seen to loop back on itself and the ventricular lead to reach towards the apex of the heart (the distal parts of the leads have been enhanced in black). In the lateral view, the atrial lead is more proximal and curves anteriorly.

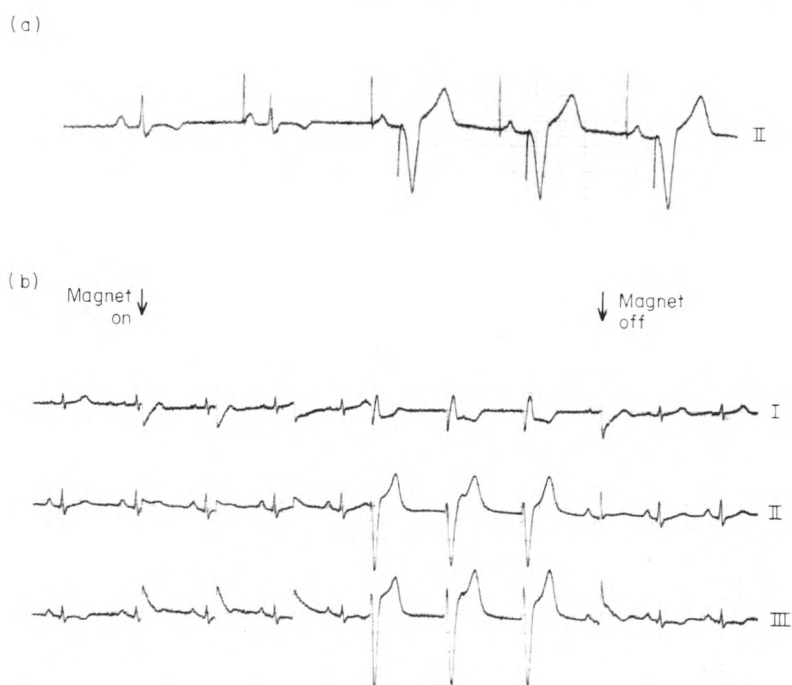


Fig. 3(a). Dual chamber pacing. The first complex is a sinus beat followed by an atrial paced beat; a ventricular complex occurs simultaneously with the ventricular pacing spike. The third, fourth and fifth beats show pacing of both the atrium and ventricle. **(b).** Sinus rhythm is interrupted by ventricular pacing with the application of a magnet. The first three complexes after application of the magnet show a pacing spike that occurs within the refractory period and fails to cause ventricular depolarisation. After the fourth complex, the pacing spike occurs late enough after the QRS complex to cause ventricular depolarisation.

Pre-operative assessment

It is important to establish whether the pacemaker is essential to maintain the heart rhythm all the time, i.e. is the patient 'pacemaker-dependent'. The patient is likely to be 'pacemaker dependent' if the ECG rhythm shows constant

pacing, but if pacing spikes are not seen or if they are intermittent then it is likely that the patient's own rhythm will maintain the heart beat if the pacemaker malfunctions during surgery. If there is any doubt as to whether the pacemaker is capable of stimulating the heart, it may be activated by placing a magnet over the pulse generator (Fig.

3). All patients with a permanent pacemaker should have the device checked at least annually and it is prudent to ask if this has been done. It is also important to assess if the patient has any associated heart disease, such as congestive cardiac failure or ischaemic heart disease, which may affect anaesthetic management. Electrolyte abnormalities, especially those of plasma potassium, should be corrected as these may interfere with normal pacemaker function and predispose to arrhythmias.⁶

The presence of a permanent pacemaker does not usually influence the choice of drugs for anaesthesia. There is a theoretical risk that marked muscle fasciculation induced by suxamethonium may cause inhibition of the pacemaker if this activity is sensed by the pacemaker and interpreted as myocardial activity, and this drug is best avoided unless there is a clear indication for its use.⁶ The risk of developing infective endocarditis on the implanted lead is very small and prophylactic antibiotics are not usually recommended unless the patient appears to be at particular risk.^{7,8}

'Pacemaker syndrome' may occur in patients with VVI pacemakers. A dramatic decrease in arterial pressure and cardiac output may occur with the onset of ventricular pacing especially if the patient has retrograde (i.e. ventriculo-atrial) conduction. Symptoms are caused probably both by loss of atrioventricular synchrony and by reflex vasodilatation secondary to activation of atrial stretch receptors.⁹ Patients may be helped temporarily by a reduction in pacemaker rate so that sinus rhythm predominates, but the pacemaker may need to be replaced by one that allows the preservation of synchronous atrioventricular contraction. The hypotensive response of the 'pacemaker syndrome' during general anaesthesia may be accentuated by the vasodilating effects of the anaesthetic agents, and result in a dramatic and profound decrease in arterial pressure; the pacemaker rate may need to be programmed urgently below the sinus rate or the sinus rate increased with atropine or isoprenaline.

Intra-operative management

The principal risk to the patient with a permanent pacemaker during surgery is the use of diathermy, which may affect the pacemaker in several ways.^{10,11} The internal mechanism may be damaged if diathermy is applied close to the pacemaker. Ventricular fibrillation may be induced if the diathermy current is channelled along the pacemaker lead. The myocardium at the tip of the lead may be subject to injury by burning and pacing may become ineffective subsequently. Diathermy may simulate the electrical activity of myocardial contraction and cause the pacemaker to be inhibited; the heart will stop if the patient is pacemaker-dependent. The diathermy impulse may simulate also the radiofrequency impulse by which the pacemaker can be reprogrammed to different settings (phantom reprogramming) and the pacemaker may start to function in an entirely different mode.^{11,12}

It was recommended formerly that diathermy interference which caused troublesome pacemaker inhibition could be overcome by placing a magnet over the pacemaker to make it function at a fixed rate.¹³ This is potentially dangerous; many modern pacemakers can be programmed only when activated by a magnet and phantom reprogramming is therefore more likely to occur.^{11,12,14} A more satisfactory arrangement may be to programme the pacemaker to a

fixed-rate (nondemand, e.g. VOO) for the duration of the operation. Diathermy should be avoided if possible in patients with a permanent pacemaker because of these problems.

Diathermy is virtually essential during some procedures, such as transurethral resection of the prostate. The risk may be minimised if the ECG and pulse are monitored when diathermy is used so that interference with pacemaker function is detected promptly. Scrupulous attention must be paid to the connexion of a suitable indifferent plate (dry foil is the best material) as improper connexion may cause grounding of the diathermy current through ECG monitoring leads.¹⁵ The diathermy current must be kept away from the pacemaker and its lead.¹¹ Diathermy use should be minimised by using short bursts at the lowest effective power output, and should not be activated unless the cutting blade is in contact with the patient.¹⁵ Diathermy should not be used within 15 cm of the pacemaker or the heart, and the indifferent plate should be as far away from the pacemaker and as close to the cutting blade as possible, e.g. it should be under the thigh or buttock for prostatic surgery. The direction of the diathermy current flow (i.e. from blade to plate) should be at right angles to that of the pacemaker system.^{15,16} Bipolar diathermy, in which the electrical current flows between the two points of the forceps, should be used wherever possible, but this is of low power and is suitable only for small bleeding points. Problems should not arise if these simple precautions are observed. Pacemaker failure that occurs in a patient without an adequate intrinsic heart rhythm should be treated with isoprenaline (50–100 µg bolus, or an infusion of 1–20 µg/minute); ventricular rhythm is usually restored promptly.

Postoperative management

The appropriate cardiology department should be informed if diathermy has been used during surgery so that pacemaker settings can be checked later. Failure of the pacemaker to capture the ventricle may not be apparent until 24 hours or more after surgery if diathermy has caused myocardial injury at the pacemaker lead tip, and it is important that the pacemaker threshold is checked also. Permanent pacemakers rarely cause any problems in the postoperative period. It is often forgotten that a pacemaker may be used to help the patient during recovery from surgery. The patient with heart failure or a marked catabolic response to surgery may benefit from an increased heart rate. The paced rate may be increased simply by reprogramming the pacemaker, and the rate reduced later as necessary.

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Forum

Comparison of continuous spinal and continuous epidural anaesthesia for lower limb surgery in elderly patients A retrospective study

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Summary

This retrospective study compared continuous spinal anaesthesia with continuous epidural anaesthesia for lower limb orthopaedic surgery in the elderly. The anaesthetic records of 457 patients who received continuous spinal anaesthesia and 274 who received continuous epidural anaesthesia over a 5-year period were analysed. The patients who had continuous spinal anaesthesia were at a higher anaesthetic risk (ASA 3–4, 76% as compared with 37%, $p < 0.001$), but the incidence of failures was significantly lower (1.7%, as compared with 9%, $p < 0.001$) and fewer patients showed a decrease in mean arterial pressure of more than 30% (44%, as compared with 65%, $p < 0.001$) and/or received vasopressors (65%, as compared with 77%, $p < 0.01$). Our data show continuous spinal anaesthesia to be more reliable and to provide better cardiovascular stability.

Key words

Anaesthetic techniques, regional; epidural, spinal.

No particular anaesthetic technique has been demonstrated to be safest in geriatric patients.^{1–3} Nevertheless, for hip surgery, although mortality rate after regional anaesthesia is no better than after general anaesthesia^{4,5} regional anaesthesia in geriatric patients is reported to preserve better cerebral function,⁶ to decrease blood loss^{4,7} and to provide better protection against thrombo-embolic complications.⁷

Continuous spinal anaesthesia (CSA) was proposed almost 50 years ago,^{8,9} but was mainly investigated clinically in the '60s and '70s.^{10–13} In 1979, CSA was introduced in our hospital for lower limb orthopaedic surgery in elderly and high risk patients. Since then it has become our most frequently used technique for this population although to our knowledge no advantage of this technique over continuous epidural anaesthesia (CEA) has been reported. The purpose of this study is to compare CSA with CEA in a retrospective manner by analysing the anaesthetic records over a 5-year period, in order to determine the possible advantages or disadvantages of these techniques.

Methods

We selected and analysed all anaesthetic records of patients older than 65 years who underwent lower limb orthopaedic surgery under CSA or CEA from January 1980 to December 1984. Records from patients who underwent foot or ankle surgery were excluded. Both anaesthetic techniques were administered by residents during their training in orthopaedic anaesthesia under supervision of staff anaesthetists.

Continuous spinal anaesthesia was performed with the patient in the lateral decubitus position using an 18-gauge Tuohy needle. A 20-gauge catheter was inserted 3 cm cephalad into the subarachnoid space when cerebrospinal fluid (CSF) appeared; correct position was confirmed by

aspiration of CSF. Depending on the surgical procedure and on the patient's position, incremental doses of 1 ml of either hypobaric, isobaric or hyperbaric solutions of tetracaine or bupivacaine (concentration 2 to 5 mg/ml) were administered until an adequate sensory level and motor blockade were achieved. Additional doses of 1 ml were injected during surgery when necessary.

Continuous epidural anaesthesia was performed with the patient in the same position using a 17-gauge Tuohy needle. A 19-gauge catheter was inserted 3 cm cephalad once the epidural space was located by the loss of resistance technique. A test dose of 3 ml of 2% lignocaine or 0.5% bupivacaine with adrenaline (1/200 000) was injected before administration of the total dose, if no blood or CSF was aspirated. Additional doses of local anaesthetic were added during surgery when clinically required. All spinal catheters were immediately removed whereas some epidural catheters were left in place to provide postoperative analgesia at the end of the surgical procedure.

The following variables were analysed: age, sex, weight, ASA physical status; surgical procedures; urinary output and central venous pressure (CVP); drugs administered for pre-operative sedation. Features of the anaesthetic that were noted included: failure of regional anaesthesia, which included all patients in whom anaesthesia was not adequate and who required general or another type of regional anaesthesia; cases where regional anaesthesia was scheduled but abandoned because of lack of cooperation or difficulty in positioning the patient correctly and (or) when the catheter could not be introduced in the subarachnoid or epidural space, were excluded from the study; drug supplementation, i.e. sedatives, analgesics or antihypotensive drugs administered during anaesthesia; variation of mean arterial pressure (MAP), which was measured on admission to the hospital, before starting anaesthesia, and every 5 minutes

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Table 1. Patients' characteristics and surgical procedures. Values expressed as mean (SD) where appropriate.

	Continuous spinal <i>n</i> = 457	Continuous epidural <i>n</i> = 274
Age, years	82 (8)	76 (6)***
Body weight, kg	58 (13)	65 (13)***
Mean arterial pressure on admission, mmHg	108 (15)	106 (18)
Female/male ratio	358/99	175/99***
ASA status 1 and 2, <i>n</i>	107 (24%)	170 (62%)***
ASA status 3 and 4, <i>n</i>	350 (76%)	104 (38%)***
Repair of hip fractures, <i>n</i>	340 (76%)	104 (38%)***
Total hip or knee prosthesis, <i>n</i>	80 (18%)	139 (51%)***
Other surgical procedures, <i>n</i>	37 (8%)	31 (11%)

Statistical difference between two groups *** *p* < 0.001.

Table 2. Patients' medical conditions and therapy.

	Continuous spinal <i>n</i> = 457	Continuous epidural <i>n</i> = 274
<i>Patients with at least one of the following conditions</i>		
Congestive cardiac failure	323 (70%)	159 (55%)***
Systemic hypertension	158 (35%)	52 (19%)***
Cardiac rhythm disturbance	81 (17%)	51 (21%)
Myocardial ischaemia	92 (20%)	31 (11%)**
Mental disturbance	48 (11%)	11 (4%)**
Renal insufficiency	67 (14%)	13 (5%)***
<i>Patients taking at least one of the following drugs</i>		
Cardioactive drugs	24 (5%)	5 (2%)*
Diuretics	322 (70%)	136 (50%)***
Calcium antagonists, β -adrenergic blockers and other coronary dilators	147 (32%)	49 (18%)***
Antihypertensive drugs	117 (26%)	37 (14%)***
Bronchodilators	61 (13%)	11 (4%)***
Psychotropic agents	52 (11%)	41 (15%)
	17 (4%)	37 (14%)***
	97 (21%)	21 (8%)***

Statistical difference between two groups * *p* < 0.05; ** *p* < 0.01; *** *p* < 0.001.

during anaesthesia or even more often if necessary; duration of anaesthesia, calculated as the time from injection of the local anaesthetic to the end of the surgical procedure; amount of fluid and blood administered during the operation; type and amount of local anaesthetic drugs administered for CSA and CEA, which was expressed in quantity (mg) and volume (ml).

All results are expressed as mean (SD). Statistical differences were sought using Student's unpaired *t*-test, Wilcoxon's rank sum test or Chi-squared analysis, according to the type of variable and its distribution. A probability value <0.05 was considered statistically significant.

Results

Four hundred and fifty-seven patients with CSA and 274 with CEA entered the study. The CSA group included five patients in whom the dura was accidentally punctured while performing a CEA. The patients' characteristics and surgical procedure are summarised in Table 1. There were statistically significant differences in age (older), the female/male ratio (higher) and anaesthetic risk (higher) in the CSA group. The surgical procedures also differed significantly between the two groups; 74% of CSA patients were operated for fractures, whereas in the CEA group more than 50% were operated for hip or knee prosthesis.

Data that concerns patients' medical conditions and treat-

Table 3. Pre-operative sedation and analgesia.

	Continuous spinal <i>n</i> = 457	Continuous epidural <i>n</i> = 274
Sedatives	164 (36%)	217 (79%)***
Analgesics	64 (14%)	14 (5%)***
Combination of sedatives and analgesics	132 (29%)	28 (10%)***
None	97 (21%)	15 (6%)***

Statistical difference between two groups *** *p* < 0.001.

Table 4. Incidence of failure and subsequent anaesthetic procedures.

	Continuous spinal <i>n</i> = 457	Continuous epidural <i>n</i> = 274
Number of failures	8 (1.7%)	25 (9%)***
General anaesthesia before surgery	8	12
General anaesthesia during surgery	—	13

Statistical difference between two groups *** *p* < 0.001.

ment are presented in Table 2. More patients suffered from important medical problems and were taking medication in the CSA group. Central venous pressure was monitored in 72% of patients in the CSA group and 23% in the CEA group (*p* < 0.001) and urinary output in 82% of patients in the CSA group compared with 34% in the CEA group (*p* < 0.001). The drugs administered for pre-operative sedation (Table 3) were mostly analgesics or a combination of sedatives and analgesics in the CSA group, sedatives in the CEA group, and for statistically more patients of the CSA group no pre-operative sedation was administered.

The incidence of failure and the subsequent anaesthetic procedure are presented in Table 4. There were statistically more failures with CEA (9%) than with CSA (1.7%). All failures in CSA and 12/25 failures in CEA were recognised before the surgical incision. General anaesthesia was administered to 11 patients in the CEA group because of insufficient anaesthesia detected during the surgical procedure. In addition two CEA patients received general anaesthesia because of the occurrence of tonic-clonic movements that suggested local anaesthetic toxicity. No major cardiac or respiratory complication occurred in any group.

Hypobaric local anaesthetic was used in 187 patients, in the CSA group, hyperbaric in 132, isobaric in 78 and a combination of these different techniques in 52 patients. Tetracaine was administered to 356 patients at a mean dosage of 9.1 (SD 4) mg and a mean volume of 4.5 (SD 2.1) ml. Bupivacaine was administered to 41 patients at a mean dosage of 13.5 (SD 6.2) mg and mean volume 2.6 (SD 0.8) ml. Both drugs were administered to the 52 remaining patients [tetracaine 7.5 (SD 5.7) mg and 3.7 (SD 2.0) ml; bupivacaine 8.5 (SD 4.4) mg and 1.6 (SD 0.6) ml].

The following drugs were administered in the CEA group: bupivacaine to 83 patients at a mean dosage of 122 (SD 50) mg and mean volume of 20.2 (SD 6.7) ml, and a combination of bupivacaine [83 (SD 37) mg, 16 (SD 7) ml] and lignocaine [228 (SD 93) mg, 11.7 (SD 4.5) ml] to 152 patients. Besides these two drugs 2-chloroprocaine or etidocaine were added to obtain a more rapid onset or more profound motor blockade in 14 patients.

The anaesthesia characteristics presented in Table 5 do not include the 33 cases where regional anaesthesia was unsuccessful. The duration of anaesthesia was longer with CEA. There was no significant difference in the two groups with regard to MAP before anaesthesia, but a clinically important decrease in MAP during anaesthesia was noted

Table 5. Anaesthesia characteristics. Values expressed as mean (SD) where appropriate.

	Continuous spinal <i>n</i> = 449	Continuous epidural <i>n</i> = 249
Duration of anaesthesia, minutes	168 (51)	192 (54)***
Mean arterial pressure before anaesthesia, mmHg	103 (14)	101 (13)
Patients presenting a decrease in mean arterial pressure of >30%	199 (44%)	149 (65%)***
Patients receiving mephentermine sulphate	296 (65%)	193 (77%)**
Mean dose of mephentermine sulphate, mg	22 (14)	25 (15)
Patients receiving		
sedatives	113 (25%)	50 (20%)
analgesics	37 (8%)	20 (8%)
combination of sedatives and analgesics	39 (9%)	21 (8%)

Statistical difference between two groups ** $p < 0.01$. *** $p < 0.001$.

in significantly more patients in the CEA group and administration of antihypotensive drugs during the anaesthesia was also more frequent in this group. A similar number of patients in the two groups received sedatives or analgesics during the operation. The amount of infused crystalloid [1530 (SD 750) ml in CSA versus 1750 (SD 900) ml in CEA] colloid or blood [660 (SD 500) ml in CSA versus 740 (SD 450) ml in CEA], was comparable.

Discussion

This study shows that for lower limb surgery in the elderly, CSA had fewer failures and provided better cardiovascular stability. Anaesthetic and surgical risk in the CSA patients were higher than in the patients of CEA group, but the incidence of clinically important decrease in MAP was 30% lower and antihypotensive drugs were less often administered. These findings can be attributed to the fact that CSA allows administration of small incremental doses of local anaesthetics at different concentrations and baricity according to the need of the patient, whatever surgical procedure and position are required. Thus optimal sensory and motor blockade can be more easily obtained and controlled than with CEA, where large doses of local anaesthetics have to be administered. The better cardiovascular stability observed in CSA patients is most probably as a result of the more easily controlled sympathetic blockade, although the level of anaesthesia was not evaluated because the data were unreliable. The higher frequency of CVP monitoring in CSA could have allowed a more appropriate fluid administration and also helped to prevent severe arterial hypotension.

The 1.7% of failure in the CSA group is similar to or lower than the incidence reported recently for the same technique^{14,15} and is much lower than for single dose spinal anaesthesia.¹⁶⁻¹⁸ The incidence of failed CEA was higher (9%) when compared with other publications.^{19,20} This difference is probably related to the advanced age of the patients²¹ and the relative inexperience of the anaesthesiologists.^{19,21} However, CSA had five times fewer failures than CEA. A large number of CSA patients received analgesics for premedication which could have contributed to the lower failure rate, but this factor is probably not important since in this group there was also a much higher percentage of patients who did not receive any drugs pre-operatively. The number of patients receiving analgesics and (or) sedatives was comparable in the two techniques during the surgical procedure. In CSA, despite a higher

incidence of pre-operative mental disorientation and pain caused by fracture, there was a significant lower incidence of failure, which suggests that even when the patient is difficult to position and does not cooperate, CSA is more easily performed than CEA. The rapid onset of sensory and motor blockade in CSA also allows early recognition of failure.

Patients who underwent foot or ankle surgery were excluded from the study because of the known difficulty to obtain adequate anaesthesia in the L₅-S₁ territory with epidural blockade²² whereas with spinal anaesthesia this problem did not occur.

Other advantages of CSA are a more complete muscular blockade and smaller dosage of local anaesthetic to obtain adequate anaesthesia, without any risks of systemic toxic effects due to absorption. The large dose of local anaesthetics administered with epidural anaesthesia means that elderly patients are at greater risk of intoxication because of their reduced clearance for local anaesthetics²³ and their reduced cardiac output and liver blood flow.²⁴

Our results suggest that CSA is an appropriate technique for lower limb orthopaedic surgery of the elderly. Anaesthetists may hesitate to perform CSA because of the possible risks of infection, neurological complications, and post-lumbar-puncture headache; the incidence of headache will be high with the use of large diameter needles. No infection or neurological problems were observed in our patients, although repeated complete neurological evaluation was not performed and no information is available on the incidence of postlumbar-puncture headache.

Lack of randomisation and the retrospective nature of the study means that our results should be confirmed with a prospective randomised study that investigates similar patients undergoing similar surgical procedures, where the incidence of failures due to technical problems and post-operative complications or side effects could be taken into account.

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Isoflurane and cerebrospinal fluid pressure—a study in neurosurgical patients undergoing intracranial shunt procedures

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Summary

The effect of isoflurane 1.0% and 1.5% with nitrous oxide on ventricular cerebrospinal fluid pressure was studied in 17 patients who underwent intracranial shunt procedures. Isoflurane at both concentrations caused significant increases in cerebrospinal fluid pressure during normocapnic ventilation, but these could be prevented by simultaneous hyperventilation or by the prior induction of hypocapnia. Decreases in mean arterial pressure occurred also, and resulted in a significant reduction in cerebral perfusion pressure in normocapnic patients.

Key words

*Anaesthetics, volatile; isoflurane.
Cerebrospinal fluid; pressure.*

Isoflurane is now regarded as the volatile agent most suitable for use during neurosurgery. It was the usual neuro-anaesthesia practice when using halothane to induce hypocapnia by hyperventilation, in order to attenuate the cerebrovascular dilating effect of this agent, and to avoid its use in patients with clinically raised intracranial pressure (ICP) until the brain is decompressed surgically.

Isoflurane, unlike halothane, does not increase cerebral blood flow (CBF) above control values during normocapnic ventilation in concentrations up to 1.5 times minimum alveolar concentration (MAC) in normal animals¹⁻³ or in patients with chronic intracranial lesions.^{4,5} Thus, it would not be expected to increase ICP. However, studies of its effect on ICP have been conflicting. No increase occurred in some investigations,^{6,7} but other authors have

reported significant increases at physiological levels of arterial carbon dioxide tension (P_{aCO_2})⁸ and also in some patients in whom moderate hypocapnia was maintained.⁹

In this investigation we have studied the effect of isoflurane on ventricular cerebrospinal fluid pressure (CSFP) during normocapnic and hypocapnic ventilation in neurosurgical patients with and without clinically raised ICP.

Materials and methods

The investigation was approved by the Research Ethics Committee of the Birmingham Central Health District. Seventeen patients (seven male) scheduled to undergo elective ventriculo-atrial or ventriculo-peritoneal shunt procedures were studied. Their ages ranged from 17 to 81

Table 1. Group 1. Pre-operative pathology.

Patient	
1	Meningioma
2	Normal pressure hydrocephalus
3	Accoustic neuroma
4	Accoustic neuroma
5	Low pressure hydrocephalus

Table 2. Group 2. Pre-operative pathology.

Patient	
1	Normal pressure hydrocephalus
2	Cerebellar tumour
3	Cerebellar tumour
4	Third ventricular cyst
5	Midbrain tumour
6	Hydrocephalus—dementia

Table 3. Group 3. Pre-operative pathology.

Patient	
1	Midbrain tumour
2	Acoustic neuroma
3	Spina bifida—hydrocephalus
4	Acoustic neuroma
5	Low pressure hydrocephalus
6	Normal pressure hydrocephalus

years and they were assigned randomly to three groups (1, 2 and 3). Their pre-operative neurological pathologies are shown in Tables 1, 2 and 3.

Premedication was with diazepam 10 mg by mouth and atropine 0.6 mg intramuscularly (10 patients), atropine 0.6 mg (one patient) or no premedication. A 1.0-mm Teflon cannula was inserted into a radial artery under local analgesia before the induction of anaesthesia; blood pressure was transduced and displayed. Anaesthesia was induced with thiopentone 3.0–5.0 mg/kg and fentanyl 100–300 µg after pre-oxygenation with 100% oxygen. Muscle relaxation for tracheal intubation was obtained with atracurium 0.5 mg/kg or vecuronium 0.1 mg/kg and ventilation of the lungs was controlled. Anaesthesia was maintained with 70% nitrous oxide in oxygen, and increments of fentanyl 50 µg and atracurium 10 mg, or vecuronium 2 mg, were given until the burr hole for the shunt procedure had been made. Isotonic saline was infused intravenously at a rate sufficient to keep the vein patent; no hyperosmolar, diuretic or steroid drugs were given.

End-tidal carbon dioxide ($Pe'CO_2$) was measured by infrared capnography (Datex Normocap). An arterial sample was also taken from each patient in groups 1 and 2 for $Paco_2$ measurement at normocapnic and hypocapnic levels of ventilation (Radiometer ABL 300). A single sample was obtained from group 3 patients during hypocapnic ventilation. Inspired and end-tidal isoflurane concentrations were measured with an infrared analyser (Datex Normac).

Group 1 (five patients). Normocapnic ventilation was maintained with a minute volume of 3–4 litres. Mean $Pe'CO_2$ was 4.8 kPa, and mean $Paco_2$ 5.0 kPa. A lateral ventricle was cannulated and a Holter catheter connected to 200 cm of manometer tubing, after preparation of the burr hole. The system was allowed to fill with cerebrospinal fluid; care was taken to avoid any fluid loss. Ventricular CSFP was transduced and displayed; zero calibration was at mid-cranial level. Isoflurane 1.0% was added to the inspired gases after a control measurement of mean CSFP had been made. CSFP was monitored for 20 minutes in four patients, but hyperventilation was started more rapidly

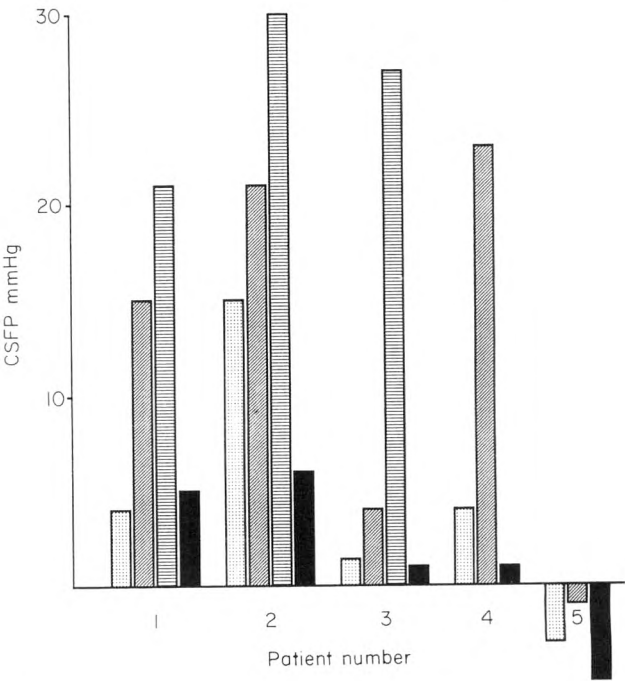


Fig. 1. Ventricular cerebrospinal fluid pressure (CSFP) during normocapnic ventilation (□) (baseline), during normocapnic ventilation with isoflurane 1.0% (▨), or 1.5% (▩); and during hyperventilation with isoflurane 1% (■).

in the fifth (No. 4), because of the large increase that occurred. Three patients also received isoflurane 1.5%; hyperventilation was started within 5–10 minutes in these patients because of substantial increases of CSFP. All patients were hyperventilated by increasing the minute volume to 8–9 litres. $Pe'CO_2$ was reduced to a mean of 3.1 kPa, and $Paco_2$ to a mean of 3.3 kPa. The isoflurane concentration was set to 1.0% during hyperventilation.

Group 2 (six patients). Normocapnia was maintained until a baseline measurement of CSFP had been obtained (mean $Pe'CO_2$ 5.0 kPa and mean $Paco_2$ 4.9 kPa). Isoflurane 1.0% was then added with simultaneous hyperventilation. Three patients also received isoflurane 1.5% after 20 minutes.

Group 3 (six patients). Hyperventilation was started immediately after induction of anaesthesia. The control measurement of CSFP was made at a mean $Pe'CO_2$ 2.9 kPa and a mean $Paco_2$ 3.0 kPa. Six patients received isoflurane 1% for 20 minutes; four also received isoflurane 1.5%.

Statistical analysis. The cerebral perfusion pressure (CPP) was calculated for each patient by subtracting the CSFP from the appropriate mean arterial pressure (MAP). The MAP during surgery and immediately before isoflurane administration was used as the control baseline for CPP. Tests were made of the equality of variance in the different groups under the differing anaesthetic conditions. The variances were found to be acceptably equal, and *t*-tests were used to analyse differences between the various groups. One- and two-way analyses of variance were also carried out and where significant results were found the regimen or group responsible was identified using the Newman-Keuls procedure. Regression tests of the relationships between CSFP or CPP changes and isoflurane concentration were also carried out.

Results

Changes in CSFP from baseline values during isoflurane administration in the three groups are depicted in Figures

Table 4. Mean (SEM) cerebrospinal fluid pressure (CSFP), mean arterial pressure (MAP) and cerebral perfusion pressure (CPP) before isoflurane, and during administration of isoflurane 1% or 1.5%.

	Group 1 (n = 5)	Group 2 (n = 6)	Group 3 (n = 6)
CSFP before isoflurane (mmHg)	4.4 (2.9)	8.3 (2.1)	8.2 (3.3)
Isoflurane 1.0%	12.4 (4.7)*	7.0 (2.4)	7.7 (3.4)
Isoflurane 1.5%	26.0 (2.6)**	5.3 (2.0)	9.0 (4.0)
Hyperventilation	1.6 (1.9)	—	—
MAP before isoflurane (mmHg)	116.2 (6.2)	121.8 (4.5)	99.6 (6.3)
Isoflurane 1.0%	88.0 (6.8)***	98.1 (10.4)**	87.6 (5.1)*
Isoflurane 1.5%	75.0 (3.2)**	69.2 (7.3)***	77.5 (4.7)*
CPP before isoflurane (mmHg)	110.1 (7.2)	113.5 (3.3)	91.5 (6.5)
Isoflurane 1.0%	75.6 (7.2)***	91.2 (11.0)*	80.0 (6.1)
Isoflurane 1.5%	49.0 (5.5)**	70.7 (11.9)*	65.0 (7.4)*

* p < 0.05; ** p < 0.02; *** p < 0.002 compared to measurement before isoflurane.

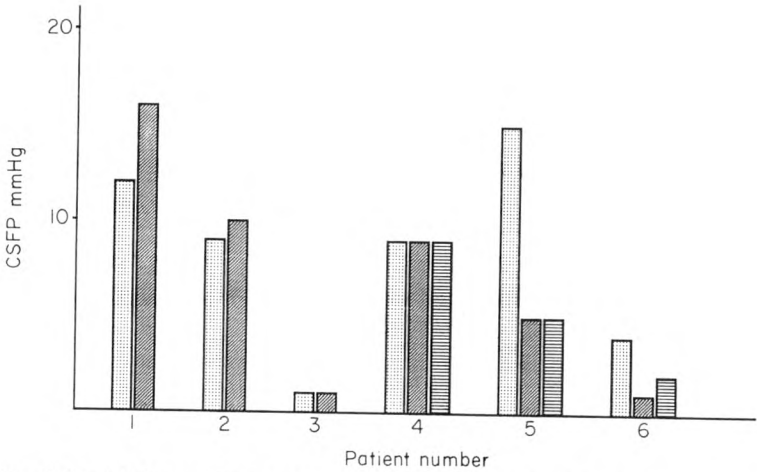


Fig. 2. Ventricular cerebrospinal fluid (CSFP) pressure during normocapnic ventilation □, and during hyperventilation with isoflurane 1.0% ▨ or 1.5% ▩.

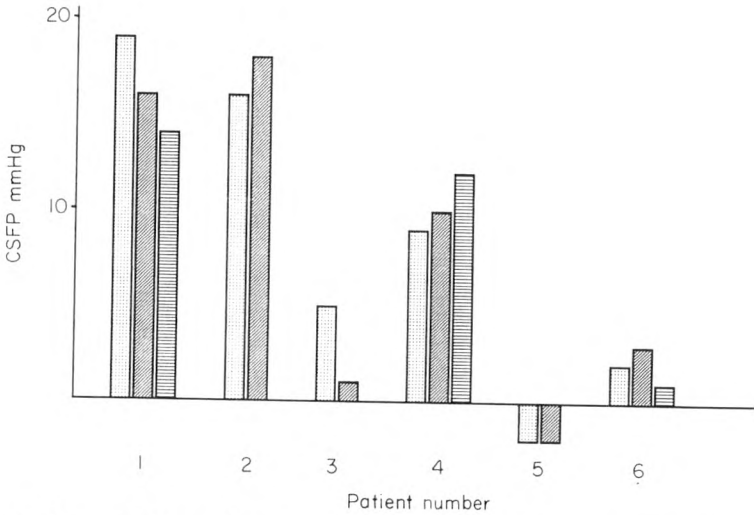


Fig. 3. Ventricular cerebrospinal fluid pressure (CSFP) during hyperventilation before □, and during administration of isoflurane 1% ▨ or 1.5% ▩.

1, 2 and 3. Changes in CSFP, MAP and CPP are tabulated in Table 4.

Ventricular CSFP. Isoflurane 1.0% increased the CSFP from baseline values in all patients in group 1 (p < 0.02). This increase was greater in those patients who received the higher concentration of 1.5%. There was a consistent trend with increasing levels of isoflurane concentration in

all patients, and a regression test demonstrated that this trend was very unlikely to be due to chance (p < 0.01). Hyperventilation decreased the CSFP in all patients to a value not significantly different from the baseline measurement. There were no statistically significant changes from baseline values during administration of isoflurane in either concentration in groups 2 and 3.

Mean arterial pressure. MAP after induction of anaesthesia was consistently lower than the pre-anaesthetic level, but increased with surgical stimulation. Isoflurane 1.0% reduced MAP significantly from the pre-isoflurane level in all three groups ($p < 0.002$ in group 1, $p < 0.02$ in group 2 and $p < 0.05$ in group 3). Isoflurane 1.5% caused a further decrease.

Cerebral perfusion pressure. Isoflurane 1.0% reduced CPP significantly in group 1 patients ($p < 0.02$). Any reduction that occurred in groups 2 and 3 was of no statistical significance.

Discussion

Recent reports have suggested that isoflurane in concentrations up to 1.5 MAC does not increase cerebral blood flow, and would not be expected to increase ICP.¹⁻⁵ Inspired isoflurane concentrations of 1.0% and 1.5% were given in the present investigation; these corresponded to end-tidal values of 0.65% and 1.0%. MAC for isoflurane in middle-aged humans is 1.15¹⁰ and the addition of 70% nitrous oxide decreases this value by slightly more than 50%, i.e. to 0.5–0.6. Thus, isoflurane anaesthesia was maintained at approximately 1.0 and 1.5 MAC.

Adams and colleagues⁸ measured lumbar CSFP in patients with a mass lesion (tumour or haematoma), and reported that isoflurane 1.0% (with 60% nitrous oxide in oxygen) increased CSFP consistently in patients ventilated at normocapnia. However, these increases could be prevented by simultaneous hyperventilation to a lower P_{aCO_2} or by the prior induction of hypocapnia. Grosslight *et al.*⁹ observed that some patients with acute head injury developed a marked increase in ICP when given isoflurane despite P_{aCO_2} below 3.3 kPa. Subsequently, they studied patients who underwent elective craniotomy for brain tumour and reported that isoflurane could cause an ICP increase even when moderate hypocapnia was maintained if the CT scan showed a marked shift of midline structures. In contrast, Campkin⁶ measured cranial extradural pressure (EDP) in patients with and without clinically raised ICP and at normocapnia, and found that isoflurane caused no rise in EDP although a small but significant increase was seen with 1.5%; hyperventilation decreased EDP rapidly.⁶

The rapidity with which isoflurane increases ICP suggests a cerebrovascular response rather than an increase of tissue fluid and hence brain bulk. Isoflurane does not increase CBF, but an increase of cerebral blood volume (CBV) provides a possible alternative explanation. CBV can be determined by the measurement of gamma emission from intravenously injected ¹³¹Iodine-labelled albumin;¹¹ in animal studies isoflurane 1.4 MAC caused a 10% increase of CBV accompanied by a short-lived (approximately 20 minutes) increase in ICP.¹² This suggests that isoflurane may exert only a slight effect on cerebral resistance vessels but can cause dilatation of capacitance vessels. One further possible explanation is that increased production of CSF could be responsible. This is unlikely, however, because isoflurane, unlike enflurane, does not increase the rate of CSF formation.¹³

The findings of the present study that isoflurane increases CSFP in normocapnic patients, but that such increases can be prevented by simultaneous hyperventilation or by the prior establishment of hypocapnia, are in agreement with those of Adams *et al.*⁸ However, the magnitude of the pressure increases seen at normocapnia are at variance with a previous study in which EDP was measured.⁶ A silastic catheter which incorporates a transducer at its tip was used in that investigation; this device allows zero calibration *in situ*. Extradural pressure measurements using this catheter have been found to correlate with CSF pressure.¹⁴ A

satisfactory pressure waveform was present in the study, but it is possible that local decompression in the vicinity of the burr hole accounted for the failure to observe an increase in EDP when isoflurane was administered.

Isoflurane can cause a decrease in arterial pressure in addition to its effect on the intracranial vasculature. This is due principally to a decrease in systemic vascular resistance.¹⁵ Therefore, cerebral perfusion pressure may be affected adversely, particularly if there is a concomitant increase of ICP. In this study, isoflurane caused a decrease in MAP in all three groups at either concentration, and hence a reduction of CPP. This was most marked in normocapnic (group 1) patients in whom significant increases of ICP also occurred.

Finally, this investigation was undertaken in patients with a chronic intracranial lesion and the findings are not necessarily applicable to those with acute intracranial pathology. Scheller *et al.*¹⁶ have reported that after acute cryogenic brain injury in animals, which resulted in elevated ICP, isoflurane (1.0 MAC) caused a further increase, even when hypocapnia had been established. Thus the use of isoflurane, even when combined with hyperventilation, in patients with rapidly progressive lesions such as head injury, would seem to be inadvisable until after the brain has been decompressed surgically.

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Prevention of postdural puncture headache after spinal anaesthesia for extracorporeal shockwave lithotripsy

An assessment of prophylactic epidural blood patching

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Summary

The prevention of postdural puncture headache after spinal anaesthesia for extracorporeal shockwave lithotripsy was investigated by a controlled clinical trial which compared epidural injection of 10 ml of autologous blood with 10 ml of normal saline immediately after intrathecal injection of local anaesthetic. The incidence of postdural puncture headache was 8.3% in the group that received blood compared with 45% in the group that received saline, a significant reduction ($p < 0.01$). The incidences of backache and lower limb paraesthesiae were similar in both groups. No serious complications were reported.

Key words

Anaesthetic techniques, regional; spinal, epidural. Complications; headache.

In a recent study we demonstrated that although spinal anaesthesia is suitable for providing analgesia during extracorporeal shockwave lithotripsy with the Dornier HM3 Lithotripter, there is a 42% incidence of postdural puncture headache despite the use of a 25-gauge spinal needle.¹ This is clearly unacceptable. Several methods such as use of finer bore needles, hydration, indomethacin or prolonged recumbency have been proposed to reduce the incidence of headache but none has achieved the 100% success rate claimed in some studies that use prophylactic epidural blood patching.²⁻⁵ However, other studies using blood patches have produced less impressive results⁶⁻⁸ and therefore it was considered that a controlled clinical trial which evaluated the effect of a blood patch would be appropriate for extracorporeal shock wave lithotripsy where the postdural puncture headache rate is high.

Methods

Forty-eight unpremedicated patients undergoing extracorporeal shock wave lithotripsy with spinal anaesthesia were assigned randomly to receive either 10 ml of autologous blood or 10 ml of normal saline into the epidural space immediately after, and at the same level, as an

intrathecal injection of local anaesthetic. The patients selected were ASA 1 or 2 and between the ages of 18-60 years. Those with a history of migraine or frequent headaches and back or neurological problems were excluded.

A 16-gauge cannula with a 3-way tap was inserted intravenously with full aseptic precautions. All patients received approximately 50 ml/kg of compound sodium lactate solution intravenously and 20 mg of ephedrine intramuscularly before performance of the spinal block, to prevent severe hypotension. Spinal anaesthesia was then performed, with the patient in the lateral position, using a 25-gauge needle and 3.0-3.5 ml of heavy plain 0.5% bupivacaine. The spinal needle was withdrawn, immediately after intrathecal injection of bupivacaine, and the epidural space was located by loss of resistance to saline at the same level, with a 16-gauge Tuohy needle. The operator who inserted the cannula withdrew 10 ml of blood into a syringe by the 3-way tap and passed it to the operator performing the block. Either the withdrawn blood or 10 ml of normal saline was then injected over 30 seconds into the epidural space; the patient was unaware of the agent used. The procedure was performed once the block had reached a sensory level of T₅₋₆.

The patients were asked about the presence of headache,

Table 1. Comparison of patient characteristics and duration of treatment between the two groups. Values shown are mean (range).

	Blood patch <i>n</i> = 24	Saline <i>n</i> = 24
Males	19	17
Females	5	7
Age, years	41 (22–54)	46 (24–57)
Weight, kg	69.6 (46–81)	70.5 (49–96)
Duration of extracorporeal shock wave lithotripsy, minutes	41 (25–60)	40 (20–50)

Table 2. Incidence of headaches in the two groups.

	Blood patch <i>n</i> = 24	Saline <i>n</i> = 24
Headache Severe	1 (male)	3 (2 males, 1 female)
Moderate	1 (male)	3 (1 male, 2 females)
Mild	0	5 (3 male, 2 females)
Total	2	11*

* = *p* < 0.01.

Table 3. Comparison of backache, lower limb paraesthesiae and time to ambulation for the two groups.

	Blood patch <i>n</i> = 24	Saline <i>n</i> = 24
Backache Severe	2	1
Moderate	1	1
Mild	9	12
Total	12	14
Lower limb paraesthesiae	2	3
Ambulation Day of treatment	24	22
1 day after	0	1
2 days after	0	1

backache and loin pain, just before discharge from the lithotripsy unit, and if present, to grade them as mild, moderate or severe. The effect of changes in posture, coughing and straining were specifically inquired about in relation to headache. As the questions were put by one or other of the investigators, who were not blinded to the patients' grouping, some bias in the results obtained before discharge would be a possibility. They were given two questionnaires on discharge to be filled in 2 and 5 days after operation. These contained the same questions as outlined above and also asked patients to note the time of onset of any symptoms; the incidence of lower limb paraesthesiae, and to state when unrestricted mobilisation first began. Patients who undergo lithotripsy may suffer from loin pain at the site of shockwave entry so they were asked specifically to differentiate between that and backache. Only headaches aggravated by sitting or standing and relieved by lying down were accepted as the postdural puncture type. Statistical analysis was performed using the Chi-squared test with Yates' correction.

Results

All 48 patients returned questionnaires. The details of the two groups are shown in Table 1. There were no significant differences in age, weight, duration of treatment or sex distribution between the groups. Postoperative details about headache, backache, lower limb paraesthesiae and time to ambulation are shown in Tables 2 and 3.

The overall incidence of headache in the blood patch group was 2/24 compared with 11/24 in the control group (*p* < 0.01). In the control group, 71% of the females developed headaches compared with none in the blood patched group (Table 2). In the control group, one patient developed a headache (moderate) on the same day, six developed headaches on the second day (3 severe, 2 moderate and 1 mild), two began on the fourth day (both mild) and two on the fifth day (both mild). The only patient in the blood patch group to have a severe headache developed it on the second day and was readmitted the day after and given a second patch with 20 ml of blood, whereupon his symptoms disappeared immediately. The other blood patch group patient's headache started on the second day and was classified as moderate. All headaches which started on the first to fourth postoperative day had either disappeared or improved spontaneously by the fifth day, apart from the patient who required readmission for blood patching. The two mild headaches (control group) that appeared on the fifth day we assume resolved since nothing to the contrary was notified by these patients. There were no significant differences in postoperative backache or in the incidence of paraesthesiae between the two groups.

Discussion

Extracorporeal shock wave lithotripsy is now an established treatment for nephrolithiasis.^{9,10} The application of shockwaves is painful with the high-energy Dornier HM3 lithotripter and either general or local (epidural or spinal) anaesthesia is necessary. Local techniques allow easier placement of the patient into and out of the hoist, remove the risk of accidental extubation or disconnection whilst the patient is in the bath and reduce the incidence of emetic symptoms and sore throat postoperatively. In a recent study,¹ we demonstrated that despite the use of a 25-gauge needle, a 42% incidence of spinal headache was recorded following spinal anaesthesia. This figure surprised us in view of reports which quoted an incidence of 2.2% to 24.5% when 25-gauge needles were used.^{11,12} It is however, consistent with another study where a 37% incidence was found after use of spinal anaesthesia with a 25-gauge needle for outpatient procedures.¹³ Factors common to both studies were that the procedure was performed in relatively young patients and that no restrictions were placed on ambulation afterwards.

It is recognised that the incidence of postdural puncture headache decreases with age,¹⁴ but the effect of early ambulation is less certain. It was initially believed that the headache is aggravated by early ambulation, but subsequent studies have indicated that this may not be the case.^{8,15} An additional factor which may have contributed to the high incidence recorded in our patients is the assumption of the semirecumbent position when the patients are placed in the hoist soon after performance of the spinal tap. This may result in stretching of the dura which may in turn accentuate cerebrospinal fluid leakage from the site of the dural puncture.

The 42% incidence of postdural puncture headache recorded in our patients, whatever the aetiology, is clearly unacceptable and indicates that the regional technique of choice should be epidural blockade. However, our experience¹ concurs with the generally held view that establishment of adequate sensory blockade with an epidural technique can be time-consuming and unpredictable, and that spinal anaesthesia is quicker and more reliable. A recent report¹⁶ has also highlighted the fact that the incidence of inadequate analgesia tends to increase with the repeated use of epidural blocks in patients who undergo lithotripsy and supplementary procedures. In situations where this is

important, spinal anaesthesia may have a useful role provided that the incidence of headache can be reduced. Smaller needles may help (27 to 32 gauge)¹⁷ but at the time of this study these were not generally available and they may be technically more difficult and time-consuming to use. Indomethacin is another prophylactic measure, but a recent report has cast doubts on its efficacy.¹²

Several workers have investigated the prophylactic use of epidural blood patching, because of its proven efficacy in the treatment of established postdural puncture headache, presumably by sealing the dural rent to prevent further loss of cerebrospinal fluid. Several reports claim success rates of 100%,²⁻⁵ but for some the technique was unsuccessful.⁶⁻⁸ Use of small volumes of blood (less than 10 ml) may be the reason. Pressure symptoms during injection, such as lower limb paraesthesiae and backache, are believed to be related to the volume of blood injected and since 10 ml of blood was used successfully in the past we also chose this volume. This volume produced significant results in our study and although postdural puncture headache has been reported more frequently in women,¹⁴ it is notable that none of the females in the patched group developed headaches, compared with five out of seven in the control group (Table 2). A recent report has suggested that 15 ml may be the optimum volume.¹⁸ The patient who required a second blood patch because of the severity of the headache was over 6 ft tall and it is likely that 10 ml of blood was inadequate. Interestingly on the second occasion 20 ml were used without any problems and the headache disappeared rapidly and completely. In retrospect we believe that 15 ml of blood would have produced better overall results.

Prophylactic epidural blood patching, as described here, is technically easy to perform although the time taken is obviously longer than spinal anaesthesia alone. However, the procedure could be shortened by the use of longer 25/26-gauge needles which can be inserted through a Tuohy needle. Epidural blood patching carries a risk of infection and it has been argued that its widespread use prophylactically is not justified when the incidence of headache is in the range of 15 to 20%.¹⁹ However, the high incidence of headache in the control group (45%) in this study which confirms the figure of 42% reported previously,¹ indicates that some form of prophylaxis would be beneficial. Epidural blood patching is documented to be a very safe procedure²⁰⁻²² and risk of infection can be avoided provided strict aseptic precautions are taken. Infection was not reported in other studies when blood patching was used²⁻⁸ and did not occur in our study. It should be noted that although epidural blood patching may be associated with paraesthesia and backache,^{4,20,21} the incidence are no more frequent than that documented with epidural anaesthesia alone.²³ This suggests that complications previously attributable to epidural blood patching may be related to the technique of epidural block *per se*. Our results which show no difference in the incidence of these complications between the blood patched and control group tend to support this view.

Acknowledgments

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Failure of rectal diclofenac to augment opioid analgesia after cholecystectomy

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Summary

The analgesic efficacy of a single 100-mg suppository of diclofenac sodium given after elective cholecystectomy was studied in 30 healthy patients in a double-blind randomised controlled manner. The mean 24-hour postoperative morphine consumption of the placebo group and the diclofenac group was similar (45 mg). Analysis of the cumulative hourly morphine consumption from the patient-controlled analgesia system failed to show any statistically significant differences between the groups. Peak expiratory flow rate, forced expiratory volume at 1 second and forced vital capacity decreased 24 hours after operation to less than 50% of pre-operative values in both groups. Subjective experiences of pain, nausea and drowsiness assessed by linear analogue scoring were similar in both groups.

Key words

*Analgesia, postoperative.
Analgesics; diclofenac.*

Intramuscular injection of opioid is still the commonest method of acute pain management, although its success and patient acceptability are variable.¹ Recently, nonsteroidal anti-inflammatory drugs (NSAIDs) have been advocated as useful adjuncts to opioids with claims of improved pain control and better postoperative respiratory function.^{2–3}

Diclofenac sodium is a NSAID which has been recommended for the relief of pain and inflammation from numerous causes.⁴ These include pain after abdominal surgery^{3,5} and tonsillectomy.⁶ Rectal administration was used in the latter study. This route has the advantage over the oral route that first pass metabolism is avoided, and absorption is more rapid from the rectum than after intramuscular injection. Thus, rectal diclofenac may represent a simple and acceptable contribution to postoperative analgesia. The purpose of the present study was to assess the analgesic characteristics of a single 100 mg suppository of diclofenac sodium given immediately after cholecystectomy.

Methods

Thirty-two patients scheduled to undergo cholecystectomy gave verbal consent to this double-blind randomised controlled study, which was approved by the local ethics committee. All patients were Caucasian, aged 18–65 years and ASA grade 1 or 2; none took any regular drug therapy. Patients with a history of asthma, peptic ulceration, bleeding diathesis, hepatic or renal insufficiency or anorectal conditions were excluded.

Ventilatory function tests were performed at the time of pre-operative interview using a Vitalograph⁷ to determine three successive measurements of Forced Vital Capacity (FVC), and a mini-Wright's peak flow meter⁸ to measure Peak Expiratory Flow Rate (PEFR). The best of each set of measurements was used for analysis. Patients were also instructed in the use of a Patient Controlled Analgesia System (PCAS)⁹ and were introduced to linear analogue assessment of their experience of pain, nausea and drowsiness.¹⁰

All patients were premedicated with oral diazepam 10 mg given 1–2 hours before surgery. Anaesthesia was induced with thiopentone and tracheal intubation facilitated by the use of a non-depolarising muscle relaxant given after loss of the eyelash reflex. The lungs were ventilated artificially with 33% oxygen, nitrous oxide and a volatile agent to maintain anaesthesia. Intra-operative opioid use was limited to morphine. Surgery was performed through a subcostal incision.

Patients received either a placebo or diclofenac sodium 100 mg suppository, allocated randomly and administered by a recovery room nurse. Intravenous morphine, usually in 2 mg increments, was administered by an anaesthetist who was unaware of the treatment group if additional analgesia was required.

The patient's intravenous fluid infusion was connected by way of a one-way valve to the PCAS on return to the ward. The PCAS was programmed to deliver 2-mg doses of morphine (0.8 ml solution) on the double press of a hand-held button. The lockout interval was 10 minutes; thus the maximum hourly patient-controlled morphine dose was 12 mg. Morphine administration was charted by a pen recorder. Additional prescriptions of intramuscular morphine (5–10 mg) and prochlorperazine (12.5 mg) were available if required. Each patient was reviewed intermittently by one of the authors. Linear analogue assessments of pain, nausea and drowsiness since surgery, were completed by the patient after 24 hours; comments on the technique were sought and respiratory function tests were repeated.

Parametric data were compared using unpaired Student's *t*-test and the Wilcoxon Rank Sum test was used for non-parametric data. A *p* value of less than 0.05 was interpreted as an indication of statistical significance.

Results

Two patients were excluded because of PCAS malfunctions as a result of faulty syringe changes. Data for analysis were available therefore from 30 patients who underwent elective

Table 1. Demographic data, expressed as mean (SD).

	Placebo (n = 15)	Diclofenac (n = 15)
Sex (M:F)	4:11	3:12
Age, years	48.0 (10.1)	43.1 (10.1)
Weight, kg	69.5 (11.8)	76.4 (19.0)
Height, cm	165.0 (11.0)	165.0 (10.0)

Table 2. Morphine consumption (mg) expressed as mean (SD) in the operating theatre, recovery ward and during the first 24 hours of PCAS administration.

	Placebo (n = 15)	Diclofenac (n = 15)
Theatre	9.3 (1.5)	10.8 (3.4)
Recovery	1.9 (3.1)	2.0 (4.2)
24 hours after operation	44.8 (24.0)	44.6 (20.7)

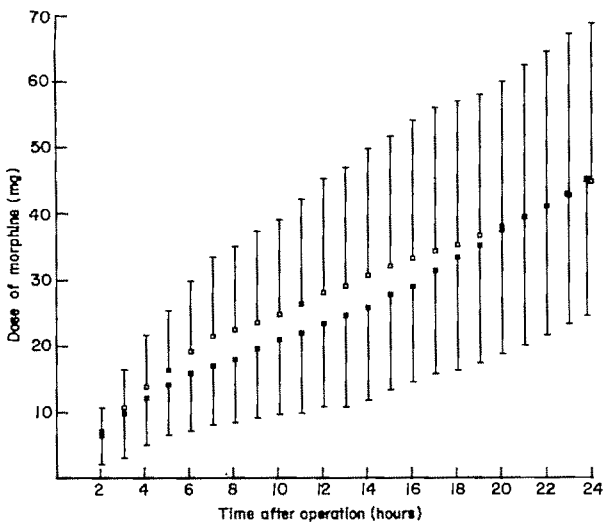


Fig. 1. Mean cumulative morphine consumption (mg) in the placebo (○) (n = 15) and the diclofenac (■) (n = 15) groups. Bars represent SD.

cholecystectomy through a subcostal skin incision. Fifteen received diclofenac sodium and 15 were given a placebo suppository. The groups were well matched for age, sex, weight and height (Table 1).

The mean (SD) duration of anaesthesia and surgery was 97.4 (23.5) minutes for the placebo group and 104.1 (43.2) minutes for the diclofenac group. The combined durations of transfer to, and stay in, the recovery room were 68.4 (15.9) minutes and 70.3 (29.3) minutes respectively. All suppositories were inserted within 40 minutes of completion of surgery. There were no significant differences in the quantities of morphine used either in theatre (determined by the anaesthetist), in the recovery room or in the ward (determined by the patient) (Table 2). However, there was considerable interpatient variation about these means (Table 2). The interpatient and inpatient range of hourly morphine supplied by PCAS was similar (0–8 mg; 0 to 4 doses for each group).

Only one patient required additional intramuscular analgesia in the ward. This occurred soon after a 137-minute recovery period without analgesia. She settled subsequently and used the PCAS satisfactorily. Analysis of the mean 24-hour postoperative morphine consumption, in hourly intervals on a cumulative basis (Fig. 1), or in 4-hourly consecutive epochs (Fig. 2), showed no statistically significant differences between the groups. The pre-operative PEFR of all subjects, corrected for age, sex and height, was within normal limits on a Gregg and Nunn Nomo-

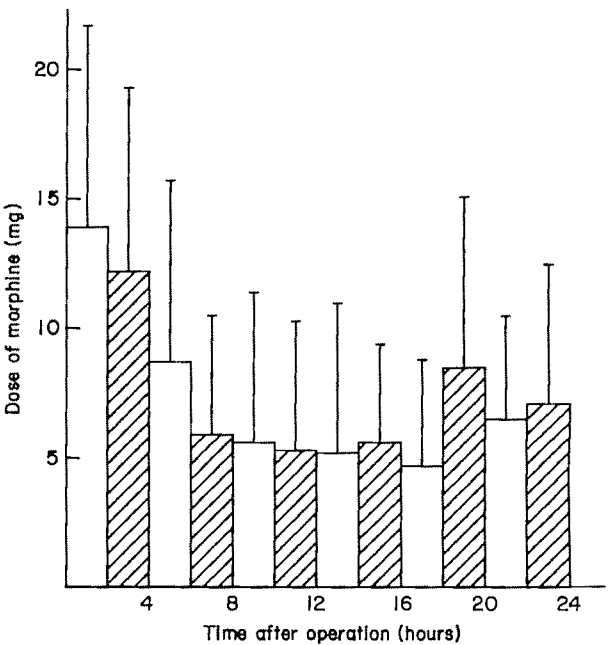


Fig. 2. Mean 4-hourly morphine consumption (mg) in the placebo (□) (n = 15) and the diclofenac (▨) (n = 15) groups. Bars represent SD.

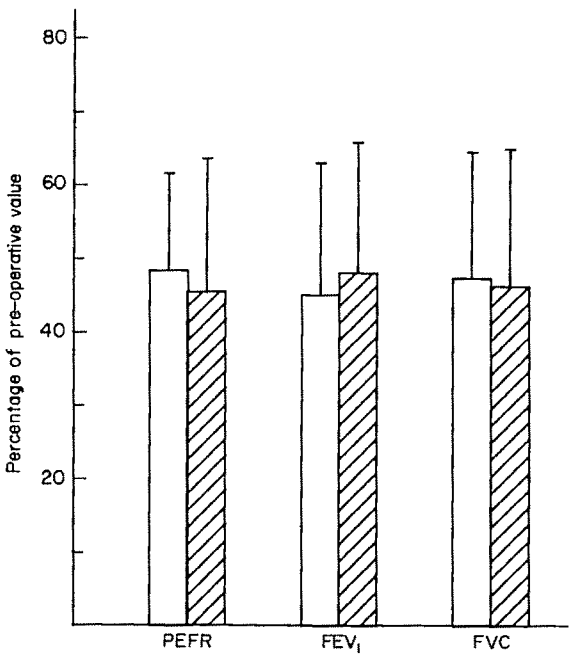


Fig. 3. Pulmonary function tests 24 hours after operation expressed as a percentage of the pre-operative value in the placebo (□) (n = 15) and the diclofenac (▨) (n = 15) groups. Bars represent SD. PEFR, peak expiratory flow rate; FEV₁, forced expiratory volume at 1 second; FVC, forced vital capacity.

gram.¹¹ The mean PEFR expressed as a percentage of pre-operative value declined in each group to less than 50%. The changes in FVC and FEV₁ were similar to those of PEFR (Fig. 3). There were no significant differences between the groups.

The number of doses of antiemetic used by each group was between 0 and 3 (mode 2) in the diclofenac group and 0–4 (mode 1) in the placebo group. This difference was not statistically significant. Linear analogue scores for pain, nausea and drowsiness in the postoperative study period did not differ between the groups (Fig. 4).

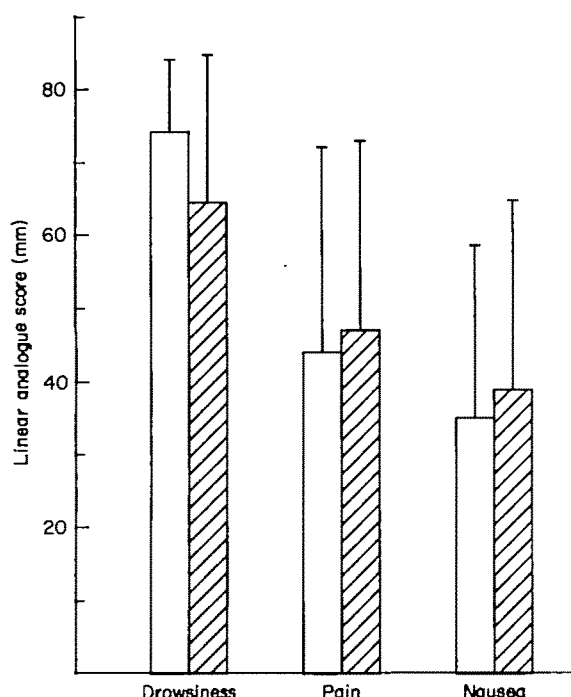


Fig. 4. Mean linear analogue scores (mm) for drowsiness, pain and nausea in the placebo \square ($n = 14$) and the diclofenac ▨ ($n = 13$) groups. Bars represent SD.

Discussion

Patient-controlled analgesia is an effective method for the relief of postoperative pain and a useful technique for the study of analgesic drugs.⁹ It removes the variability caused by nursing and ward management factors and as patients are free to titrate the dose to provide an acceptable level of comfort, the quantity of opioid used in a defined period is an objective index of the severity of the pain experienced. Comparison of different opioids may be used to elucidate their relative potencies, or the analgesic characteristics of a regimen may be deduced from its modification of the PCAS consumption in a controlled study.

Recent studies in which diclofenac sodium 150 mg was given by divided intramuscular injection,³ or by a combination of oral and rectal routes,⁵ demonstrated a reduction in opioid demands. Another study reported the beneficial effects of rectal doses of 75 mg or less in adults after abdominal surgery.¹² We chose to assess the efficacy of a single 100 mg rectal suppository because of the work of Dommerby and colleagues⁶ who used this dose immediately after operation, and in accordance with the data sheet recommendation that no more than one 100-mg suppository should be given per day.¹³

Derbyshire and Richardson⁵ found that papaveretum consumption in the first 12 hours after major gynaecological surgery was reduced by almost 50% in patients given oral diclofenac 50 mg pre-operatively. These authors reported initial subjective recovery room benefit which may be attributable to the pre-operative tablet. However, opioid supply was subject to the influences of nursing discretion, nurse availability and ward management policy during the first 12 hours after surgery.

Hodsmann and colleagues³ found a statistically significant reduction in PCAS-administered morphine consumption which was started soon after an intramuscular injection of diclofenac sodium (75 mg). This was maintained by a further similar injection 12 hours later. However pain after abdominal surgery does not have a unimodal distribution¹⁴ and upper abdominal surgery is associated with the greatest

discomfort. All patients in Hodsmann's study³ had abdominal surgery, but neither its type nor the distribution between the groups was revealed. It is therefore possible that the groups were not comparable.

The present controlled study used a sensitive objective measure of pain relief, and failed to show any analgesic benefit from a single 100-mg rectal suppository of diclofenac sodium given after surgery. Our findings cannot be explained simply on a dose-response basis in view of the benefit claimed by other investigators who used smaller doses. The bio-availability of oral and rectal diclofenac sodium is almost 100%, and peak plasma concentrations are reached approximately one hour after rectal administration and 2 hours after oral administration in humans.¹⁵ It is therefore unlikely that the difference between our findings and those of others can be explained by any pharmacokinetic disadvantage.

Patients settled to a relatively constant rate of self-administered intravenous morphine use (almost 2 mg/hour) within 4 hours of surgery. The mean pain score of approximately 45 mm (SEM 8) supports the concept that patients will tolerate some discomfort when allowed to control their analgesia personally in an attempt to minimise associated side effects.

We found a decrease in postoperative respiratory function comparable with that in other studies of upper abdominal surgery.¹⁶ This impairment was similar in both groups of patients. The changes in FVC and FEV₁ were paralleled by the simple measurement of PEFR using a mini-Wright's peak flow meter.

We conclude that there is no clinically significant benefit from a conventional dose of diclofenac sodium given rectally soon after painful abdominal surgery. This confirms the work of Tigerstedt *et al.*¹⁷ who were unable to demonstrate any analgesic benefit in the immediate postoperative period after intravenous administration of diclofenac sodium during either abdominal or superficial surgery.

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Total intravenous anaesthesia for laparoscopy

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Summary

Two techniques of total intravenous anaesthesia for laparoscopy were compared in 80 patients. Group 1 received alfentanil, propofol and vecuronium, and Group 2 alfentanil, midazolam, ketamine and vecuronium. Haemodynamic stability after induction and the pressor response to tracheal intubation were significantly different. There was no significant difference in recovery times between the two groups and little difference in other postoperative sequelae.

Key words

Anaesthetic techniques; total intravenous.
Anaesthetics, intravenous; ketamine, propofol.

In a previous study¹ we showed that a total intravenous anaesthetic technique with a mixture of ketamine, midazolam and vecuronium was a safe, simple and reliable alternative to inhalational anaesthesia for use in the field, and the method was proposed as a substitute for use in general civilian practice. We decided to compare this technique with another form of total intravenous anaesthesia for a relatively short surgical procedure, laparoscopy.

Propofol has been used both alone^{2,3} and in combination with alfentanil⁴ to provide anaesthesia for a variety of surgical procedures. The anaesthetic sequence described by Kay⁴ is suitable for laparoscopy and more major surgery and was used as a basis for comparison. We had noted previously the marked hypertensive response to tracheal intubation, so on this occasion we added alfentanil 30 µg/kg at induction^{5,6} and excluded opioid premedication. The aims were to compare the two techniques in terms of haemodynamic stability after induction, speed of recovery and incidence of complications after operation.

Methods

Patient group. Eighty female patients scheduled for laparoscopy were included in the study. All were ASA

grades 1-2 and aged between 16-45 years. None was taking any drugs likely to modify response to the agents used and all gave informed consent to the study.

Procedure. All patients received temazepam 20 mg orally 2 hours before operation. An ECG monitor was connected and a cannula placed in a forearm vein on arrival in the anaesthetic room. Arterial pressure was observed using a Dinamap 846 noninvasive blood pressure monitor. Baseline values of blood pressure and pulse rate were recorded before induction and subsequently every 60 seconds for 10 minutes, and at 1-3-minute intervals thereafter.

The patients were allocated randomly to two groups at the pre-operative visit. Group 1 received alfentanil 10 µg/kg, propofol 2 mg/kg and vecuronium 0.1 mg/kg at induction. Anaesthesia was maintained with a mixture of propofol 200 mg and alfentanil 1 mg at six times the induction dose in ml/hour delivered by a syringe pump (Imed 800). Group 2 were given alfentanil 30 µg/kg, ketamine 1 mg/kg, midazolam 0.07 mg/kg and vecuronium 0.1 mg/kg at induction. Maintenance was provided by a continuous infusion of ketamine 200 mg and midazolam 5 mg made up to 50 ml with NaCl and delivered by syringe pump at a rate, equal to half the patient's body weight in kg, in ml/hour.

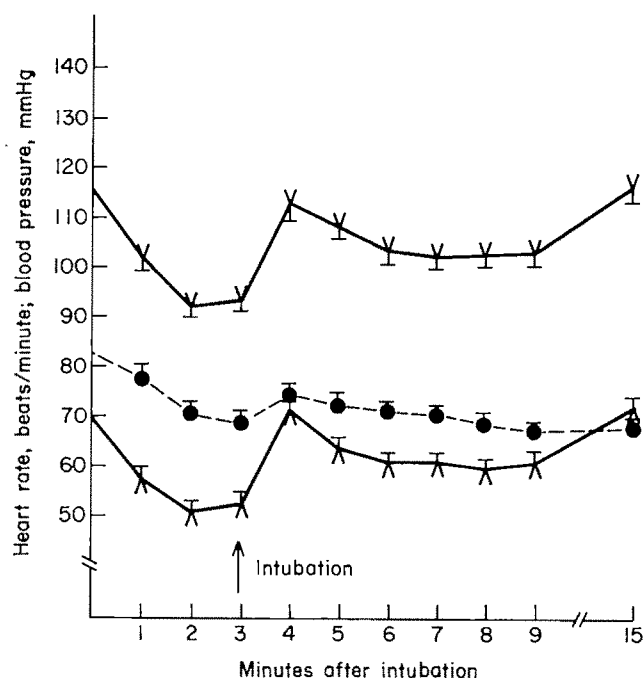


Fig. 1. Propofol group. Mean (SEM) changes in systolic (v—v) and diastolic (x—x) arterial pressures, and heart rate (●—●).

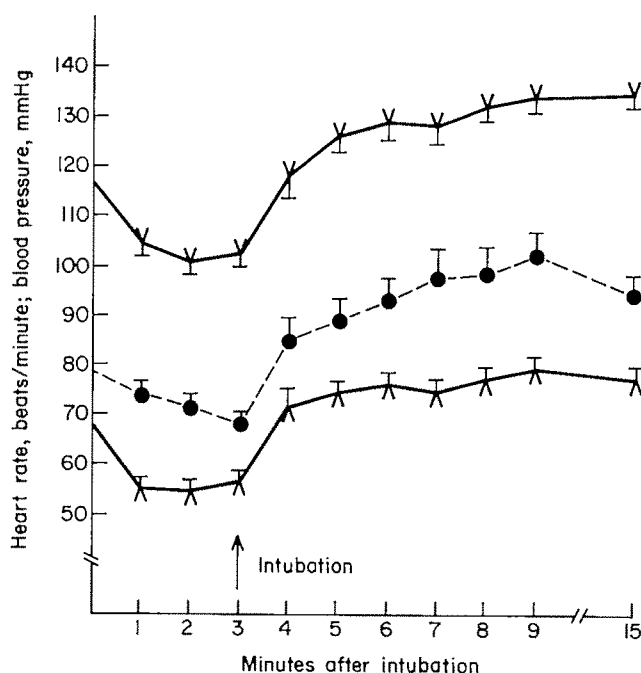


Fig. 2. Ketamine group. Mean (SEM) changes in systolic (v—v) and diastolic (x—x) arterial pressures, and heart rate (●—●).

Discussion

This study again shows that total intravenous anaesthesia with a mixture of ketamine and midazolam is a suitable means to produce satisfactory general anaesthesia in paralysed patients. It compares favourably with a propofol and alfentanil technique in terms of recovery and complications after operation.

There were no problems at induction in either group and no patient in the study had any recollection of any operative event. Propofol and alfentanil, because of their phar-

macokinetic profiles, should provide more rapid recovery than midazolam and ketamine. This was found not to be the case. Early recovery, as assessed by the ability to answer simple questions, was similar for both groups, although eye opening was significantly earlier with ketamine ($p < 0.001$). We now recommend that the ketamine/midazolam infusion be continued until reversal in view of the rapid return of consciousness after discontinuation of the infusion. There was no formal testing of late recovery but all patients were discharged from hospital within 24 hours without apparent ill effect.

Table 3. Recovery data.

	Propofol n = 40	Ketamine n = 40
Eye opening, minutes (SEM)	7.0 (0.4)	3.0 (0.4)*
Name, age, ward; minute (SEM)	12.1 (0.7)	12.2 (1.1)
Vomiting	17.5%	27.5%
Acceptability	92.5%	87.5%

* p < 0.0001.

Emergence delirium has always been a problem associated with ketamine anaesthesia and the incidence has been variously reported at between 5% and over 30%.⁷⁻¹⁰ This study confirms our previous findings¹ that, when used in this manner, the incidence of emergence phenomena is negligible. Indeed the recovery staff were usually unable to determine which anaesthetic technique the patients had received. The incidence of postoperative dreaming in the two groups was roughly comparable and only one patient in each group recorded these as unpleasant.

Patient acceptance of both techniques was good. Slightly more in the propofol group were prepared to have the same anaesthetic again but this was not believed to be clinically significant. Reluctance to have the same technique again was directly related to vomiting after operation in all cases. The incidence of nausea and vomiting after laparoscopy has been reported as high as 50% following nitrous oxide anaesthesia.¹¹ The incidence in both our groups compares very favourably with this figure. Propofol is known to produce significant hypotension after induction¹² and this was again evident in this study. Arterial blood pressure had returned to normal by intubation but showed a significant decrease thereafter (p < 0.01 at 8 minutes) before it returned to baseline. This may preclude the use of this technique for shocked or hypovolaemic patients.

Ketamine on the other hand has been shown to produce an increase in both heart rate and arterial blood pressure in otherwise healthy patients.^{13,14} However in this study arterial blood pressure showed a significant decrease (p < 0.01) at 1 and 2 minutes after induction. This is contrary to our previous findings with this technique and can be attributed to the addition of alfentanil 30 µg/kg to the induction sequence. Alfentanil in this dose has previously been reported⁶ to cause significant hypotension after thiopentone induction. Arterial blood pressure returned to normal following tracheal intubation and was then significantly elevated above baseline readings (p < 0.01). It appears that either, despite the initial decrease in arterial pressure, alfentanil 30 µg/kg is ineffective in the prevention of the pressor response to intubation, or that this is a manifestation of the delay in the cardiostimulatory effect of ketamine as proposed by Dundee *et al.*¹⁴ Alternatively the increase in blood pressure may be because the effect of alfentanil was wearing off and unmasked the cardiostimulatory effects of ketamine. We are currently investigating the effect of the addition of a small amount of alfentanil to the infusion.

In conclusion, we believe we have shown that total intra-

venous anaesthesia based on ketamine and midazolam is comparable to a technique using propofol and alfentanil. The addition of alfentanil 30 µg/kg at induction causes an initial decrease in arterial blood pressure but fails to prevent the pressor response to intubation.

On the basis of this study we propose two changes to our technique for use in the field. Firstly, in the shocked patient alfentanil should either be omitted or given in much reduced doses to avoid undesirable hypotension. Secondly we now intend that, because of the rapid recovery after termination of the ketamine/midazolam infusion, the vecuronium be administered through a separate syringe to allow it to be turned off early enough to ensure adequate return of neuromuscular function without lightening of anaesthesia.

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SPECIAL ARTICLE

Anaesthesia and the law

Two cases of oesophageal intubation

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Two recent coroners' inquests found that the incorrect placement of the tracheal tube led to the patients' deaths while they were undergoing routine operations.

Positioning the tracheal tube

Mrs M.B. (57), was admitted to Selly Oak Hospital in Birmingham on 4 August 1987 for a routine cataract operation. Unfortunately, a locum anaesthetist (K.T.) wrongly inserted the tube into the patient's oesophagus. A few minutes later the patient collapsed, whereupon the consultant was summoned to help, leaving his own patient until the senior registrar (A.M.) arrived. The registrar discovered the misplaced tube, and relocated it, but the patient had by then been deprived of oxygen for some 14 minutes. She suffered severe brain damage, and died 2 months later from bronchopneumonia.

Dr L. Groves, a consultant anaesthetist who had been charged with carrying out an investigation said at the inquest which was held in April 1988, that the *difficulties in directing the tube into the larynx were an almost daily occurrence, but that this was usually noticed long before any damage could be done.* (Emphasis supplied). The deputy coroner, Mr C. Ball, recorded a verdict of accidental death.

Transfer of patient to theatre causing displacement of tracheal tube into oesophagus during anaesthesia

On 30 March 1988, Mrs A.I.D., a 41-year-old Asian woman with dark skin, was admitted as a day case to Staincliffe General Hospital for a routine cystoscopy and urethral dilatation. No premedication was given as the procedure was not expected to take more than 10 minutes. The patient was 'massively obese', though otherwise reasonably fit, so the anaesthetist, a Senior House Officer (M.R.) (8 years qualified with 4 years in anaesthetics), considered that in the circumstances, mask anaesthetic was contraindicated particularly since the patient was to be placed in the lithotomy position required for a cystoscopy.

Metoclopramide and atropine were administered intravenously followed by etomidate and suxamethonium. The patient's lungs were manually ventilated with a 'standard mixture' of 66% nitrous oxide, 33% oxygen and 1% enflurane; a tracheal tube was introduced and secured for the continuation of anaesthesia. The patient was then moved from the anaesthetic room onto the operating table. An ECG monitor was attached, the tube checked and the patient's pulse and colour continuously monitored.

However, when the surgery was concluded the anaesthetist was unable to awaken the patient, 100% oxygen was given. The anaesthetist said the patient's pulse had been strong throughout the operation, but that on its completion, the pulse 'began to slow and fade away' and he thought then that he could detect cyanosis from observing

the pharynx. Cyanosis is generally more difficult to detect in dark-skinned people and it was apparently not noticeable elsewhere on the patient. Unable to account for, or to reverse, the patient's collapse, he summoned the consultant who arrived about a minute later. By then the patient's legs had been released from the lithotomy position and she was lying flat. Her chest was moving quite normally, but she was pulseless with a very slow heart rate on the ECG. Cardiac massage was started and a drip set up. The consultant checked and repositioned the tracheal tube which she found lying in the oesophagus, but was unable to save the patient's life.

The coroner, Mr J.A. Turnbull returned a verdict of misadventure finding that the patient had died of hypoxic brain damage when the tracheal tube used for introducing anaesthetic gases became displaced probably 'when the lady was being transferred from the anaesthetic room to the operating theatre . . .'

Few warning signs for onset of hypoxia

The medical evidence demonstrated that the onset of cyanosis is much harder to detect in a dark-skinned patient. Although there are new monitoring devices, (e.g. the oximeter) this was not available in Dewsbury.

Obesity may add further to the anaesthetist's difficulties (and therefore to the risks for the patient). It was the anaesthetist's evidence that 'it is a known fact that people who are short-necked, bull-necked or have receding chins are often difficult to intubate'. The anaesthetist said he had been unable to view the vocal cords but that he was able to view the top of the larynx and the back of the larynx and to observe that the tube went in front of the visible part of the larynx. Even when cyanosed and collapsed there were none of the usual signs to indicate that the tube was in the wrong place. The anaesthetic gases were going into the stomach, pushing the diaphragm and moving the chest. When this happens, the upper part of the stomach becomes distended with gas or gas may escape up the pharynx into the mouth causing a characteristic noise. Here, although gas was being blown into the stomach, its distension was not visible as the patient already had a protuberant abdomen and there were no 'mouth noises'. However, arguably, there are simple tests which can be performed to check that the tube is correctly positioned.

The consultant anaesthetist accepted at the inquest that there were several points during which the tube could be pulled and dislodged—in particular when the patient was moved from the anaesthetic room to the operating table. It would seem prudent therefore to check that the tube had not become dislodged at any of these points, particularly when dealing with patients who could be difficult to manage because of their size.

Comment

Monitoring the movement of the patient's chest may, by itself, be of limited value. In the Woodhouse case,¹ the patient's chest moved regularly and the bag on the ventilator was filling. However, since the input of fresh gas was set too low, the patient was being ventilated with a

dangerously hypoxic mixture. He remained deeply cyanosed for 20 minutes before the error was discovered.

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Occasional paediatric resuscitation: misuse of equipment

A.G.P. Laxton, FFARCS

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An alternative to sedation during regional anaesthesia

G.B.H. Lewis, FFARCS

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Low-dose heparin therapy and spinal anaesthesia

The paper by Gustafsson *et al.* (*Anaesthesia* 1988; 43: 220-2), commented on the use of regional anaesthesia in patients who received low-dose heparin prophylaxis. This prompted us to review the experience of this procedure in patients on low-dose heparin in our own institution.

Ninety-nine epidural and 37 spinal techniques were performed since 1984 on patients given heparin 5000 units 2 hours pre-operatively and continued into the postoperative period. All patients were scheduled for elective abdominal or thoraco-abdominal procedures. General anaesthesia was first induced and then the epidural or spinal was performed using the midline puncture technique and a 16-gauge Tuohy needle or a 22-gauge spinal needle respectively. Epidurals were performed either as a one shot technique or with insertion of an epidural catheter depending on the duration of the operative procedure. The catheter was either removed at the end of the operation or left in place for up to 72 hours after operation to provide post-operative analgesia with a continuous bupivacaine infusion. Patients were still receiving heparin prophylaxis when the catheter was removed. Epidural blood vessel puncture occurred with an estimated incidence of 5% which is in keeping with the incidence of 2.8-11.5%, quoted by Gustafsson *et al.* If vessel puncture occurred, the catheter was withdrawn, and re-aspirated and if no blood appeared the catheter was left in place. A different interspace was selected if blood was still aspirated into the catheter. All patients were seen postoperatively by C.G. and on a daily basis if receiving continuous epidural infusions. No formal neurological assessment was performed, but there were no neurological complications reported either immediately post-operatively or when patients were subsequently seen in the outpatient clinic.

The use of regional anaesthesia in patients on low-dose heparin has been questioned^{1,2} because of the fear of a spinal haematoma. This may have devastating neurological consequences, but it is such a rare complication that its true incidence is not known. There has been no report of its occurrence in a patient on low-dose heparin prophylaxis who received a regional anaesthetic technique.³

A reduced morbidity and mortality has been demonstrated in high-risk surgical patients given a combined general plus regional anaesthetic technique, as compared with general anaesthesia alone.⁴ It is this same group of patients who have a high risk of developing thrombotic complications and who benefit from heparin prophylaxis. If heparin prophylaxis is considered a contraindication to performing a regional anaesthetic the surgical and anaesthetic team are faced with the decision between which of the two will most benefit the patient with the exclusion of the other.

The patient numbers quoted here and in the report by Alleman *et al.*³ are clearly insufficient to make a definitive statement about the risk of a spinal haematoma. It would take any one institution many years to do so. We are aware that ours is not the only centre in the UK where regional anaesthesia is done on patients who have low-dose heparin and it would be useful to see the experience of other centres reported in the literature. Total numbers may still be insufficient to make a statement concerning risks, but a body of evidence from several centres would help individual practi-

tioners faced with such patients to feel more secure in these circumstances.

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A reply

It is pleasing to see that our article is being commented on so soon after publication. All new data that throw light upon the controversial issue of regional anaesthesia and anticoagulation are valuable.

The regimen of prophylactic low-dose heparin is an accepted and, in some institutions, a more or less routinely used method to prevent postoperative deep venous thrombosis and pulmonary embolism. However, plasma heparin levels after a standard dose of 5000 IU heparin subcutaneously vary considerably among subjects, and susceptible patients may be at risk from either bleeding and haematoma formation or venous thrombosis.¹ These complications have implications for the anaesthetist, the surgeon and the patient.

The risk of the development of a spinal haematoma after central neural blockades in patients who receive low-dose heparin prophylaxis is at present unknown. The risk is not very high according to this report and that by Allemann *et al.*² which together comprise a total of 119 spinals and 204 epidurals. The available information is however insufficient to make a clear risk analysis. The risk of a spinal haematoma followed by permanent neurological damage is probably underestimated because of reluctance to report such cases. This tendency not to report may in turn be because of the complexity of causal connexions when a complication occurs. Not only heparin, but also drugs such as dextran, salicylates and others with antiplatelet effects may be involved, as well as technical problems with the spinal puncture and problems related to patient disease (alcoholism or blood dyscrasia). Therefore, controlled prospective studies with an adequate number of patients, multicentre studies that include neurological follow-up, are desirable before heparin is generally used in combination with regional blocks.

Regional anaesthesia in the pre- and/or postoperative

period is advantageous because it promotes cardiovascular stability and reduces the incidence of some pre- and postoperative complications. There are patients undergoing surgery who would certainly benefit from both heparin prophylaxis and a regional anaesthetic. Therefore, a conflict of interest may arise. A spinal haematoma which causes paraplegia is a devastating complication, so I suggest the following procedure:³ each patient should be considered individually by the anaesthetist and surgeon; a discussion of the risks and benefits should take place with the patient; and if the benefits seem to outweigh the risks, and the doctors and the patient involved are in agreement and repeated postoperative neurological assessment can be provided, then a spinal intra- or extradural technique may be performed during low-dose heparin therapy.

Induction agent for electroconvulsive therapy

We were interested to read the paper by Dwyer and his colleagues (*Anaesthesia* 1988; **43**: 459–62) about anaesthesia and electroconvulsive therapy (ECT). It is known that a bilateral grand mal convulsion must be induced for a therapeutic response to be seen after ECT.^{1,2} Dwyer states that Maletzky has shown that the benefit from ECT is related to the duration of the electrical seizure produced.³ However, the existence of a direct relationship between the efficacy of ECT and seizure duration has been questioned.^{4,5}

We have previously reported that seizure duration is significantly shorter when propofol is used as the induction agent for ECT compared with methohexitone.⁶ Dwyer, in referring to our work, has clearly not understood the significance of our use of the isolated forearm technique⁷ for the measurement of seizure duration. Results obtained using this technique are highly correlated with results derived from EEG recordings. We therefore cannot accept Dwyer's statement that it is mandatory to measure seizure duration with an EEG monitor to obtain meaningful data.

Seizure duration during ECT is influenced by many factors including the patient's current medication,⁸ the effects of ventilation,⁹ and oxygenation.¹⁰ The first ECT session should not be studied since it is known to produce prolonged seizures.^{2,11} A supramaximal stimulus must be applied¹² and ECT apparatus must be tested to ensure this. Dwyer's paper did not state whether the above variables had been taken into account in their study.

It is encouraging to see an increasing interest in the anaesthetic aspects of ECT. However, the design of any studies must take into account the existing published work on the subject for the results to be valid.

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A reply

The evidence that links benefit from electroconvulsive therapy (ECT) with duration of seizures induced is not conclusive, but is suggestive.^{1–3} Thus duration of seizure would seem to be a factor to be taken into account by anaesthetists when they select an intravenous induction agent for ECT.

We accept that seizures measured by the cuffed forearm technique are correlated with seizure duration on electroencephalogram (EEG) (as indeed are seizures measured by watching the uncuffed arm). However, the cuffed forearm technique is an indirect method of assessment of cerebral seizures and it underestimates cerebral seizure by an average 10%; the mean correlation coefficient is 0.86 and the correlation coefficient in individual patients varies between 0.66 and 0.97.⁴ Benefit from ECT has been linked with seizure duration as measured by EEG so we studied seizure duration directly (by EEG) rather than indirectly.

Our study was designed to assess the effect of two intravenous induction agents on seizure duration after ECT. We controlled for other variables by having a single anaesthetist for all treatments using a standard anaesthetic technique and using inpatient crossover control.

Seizures after ECT become shorter after successive treatments, not just after the first.⁵ Half of our patients received propofol for the first of the two treatments studied and

half received methohexitone, thereby controlling for this factor.

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Anaesthesia and thalidomide-related abnormalities

We were interested to read Dr J.W. McCrory's letter (*Anaesthesia* 1988; **43**: 613-14) on the provision of anaesthesia for a patient with thalidomide phocomelia. We were recently asked to provide anaesthesia for a patient for Caesarean section with deformities similar to Dr McCrory's patient. We also were unable to find reports in the literature which might help us with the anticipated problems.

Our patient was 25 years of age; she had a normally developed head and trunk, no arms or legs and small, deformed and rotated feet. Her hands were underdeveloped, and grew directly out of her shoulders, but they are large and mobile enough to be useful limbs. She was moderately obese; the total length of her trunk and head was 76 cm, and her normal weight was 54 kg; this increased to 70 kg in late pregnancy. She had a visible and palpable vein on the dorsum of her right hand, which was adequate for venesection for pathological tests, and a rudimentary vein on the dorsum of one foot. She was referred to one of us in early pregnancy for assessment of the likely anaesthetic difficulties. It had been already decided, in view of likely pelvic abnormalities, that she should be delivered by elective Caesarean section shortly before term. She had undergone anaesthesia several times as an adolescent; on one occasion the vein on her foot had been used for induction, and on other occasions the right internal jugular vein had been used. We were unable to obtain records of these anaesthetics.

It was found at the time of her referral that her arterial blood pressure could be easily estimated by using the paediatric cuff of a noninvasive automatic sphygmomanometer on her right hand. Also, a conventional paediatric sphygmomanometer cuff used with a carbon microphone pulsemeter gave a reading of systolic pressure in close agreement with the systolic pressure measured with the Dinamap. The cuff and pulsemeter were used at her antenatal appointments, and we decided to use the Dinamap at her delivery. The paediatric cuff was kept with the Dinamap in the labour ward throughout the last trimester of her pregnancy. She was undecided at this stage whether she would prefer general or epidural anaesthesia for her delivery; she was warned that epidural analgesia might present some difficulties.

Her pregnancy proceeded uneventfully until her membranes ruptured spontaneously at 36 weeks' gestation. Contractions did not begin immediately, but as the pregnancy was near term it was decided to proceed to immediate Caesarean section. She decided on epidural analgesia, and we agreed to attempt this.

Attempts were made to cannulate her two visible veins; the vein in the hand had been used recently to obtain blood for cross-matching and was obscured by a haematoma, and the vein in the foot proved too small for an adequate cannula. Attempts to cannulate the foot vein proved painful and distressing to the patient and resulted in involuntary movement of her foot. We then decided to attempt cannulation of the right internal jugular vein. Considerable thought had been already given to the choice of a suitable

catheter for this route; conventional cannulae or catheters were felt either to be too long and narrow to permit adequate flow for volume loading or fluid replacement, or too short to permit adequate stability within the vein. We decided to use an 8-FG catheter introducer and this was inserted into the internal jugular vein under local anaesthesia with no difficulty. A warmer was included in the infusion set in case rapid administration of fluid became necessary.

A 16-G Tuohy needle was inserted without difficulty at the L₃₋₄ interspace, and a catheter was introduced into the epidural space. Plain bupivacaine (0.5%) was injected incrementally to a total of 25 ml, to give a block to T₆ within 45 minutes. A total of 2 litres of compound sodium lactate solution was infused during this time, and her blood pressure remained stable. A live female infant was delivered; after delivery the mother developed some discomfort, and two intravenous doses of 5 mg of papaveretum were given.

This case was satisfactory but we were lucky because our patient seems not to have any spinal abnormality that would preclude epidural analgesia. An antepartum haemorrhage, had it occurred, would perhaps have caused considerable difficulties in emergency venous cannulation; we were fortunate in that she presented to us normovolaemic and well hydrated.

Like Dr McCrory, we were a little surprised at the lack of information in the literature on the anaesthetic management of these patients. We knew our patient had had several previous operations. It is also known that several thalidomide phocomelics have recently been delivered of babies. Presumably, as this small but significant population gets older more operative procedures will be required. The problems in these patients of anaesthesia for, for example, cardiac or vascular surgery would appear to be daunting. Colleagues who have given anaesthetics to these patients should publish their experiences.

In addition to this patient, and this may be mere coincidence, we have in the last 5 months provided anaesthesia for Caesarean section for an achondroplastic dwarf and for a patient with the sequelae of Still's disease who also has sickle-cell trait (this latter patient will be the subject of another case report). Pregnancy will be increasingly desired by people with severe disabilities. Nobody could disagree with the process of making more things possible for such people. However, in some people with such disabilities pregnancy can be a life-endangering condition, as severe haemorrhage would have been for our patient. She was well aware of the dangers, and accepted them cheerfully, but we consider that, as in this case, early assessment and counselling of the patient are an important part of the anaesthetic management, together with the assembling of a team with the right skills and the right equipment well in advance of the time of the delivery.

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Bad publicity

The Sunday Telegraph (31 July 1988) featured an article about a surgical team at a London teaching hospital. The article bore the characteristics of what is known as the 'human interest angle' and focused on, for example, the surgeon's penchant for fast cars and jewellery rather than anything of more medical relevance. This would not, I suspect, encourage the reader to develop great confidence in his or her medical attendants. Certainly the piece did not call to mind the phrase 'centre of excellence' to describe the featured hospital.

My main concern, however, was the portrayed attitude and behaviour of the (named) consultant anaesthetist, who was quoted repeating the old cliché about anaesthesia being 90% boredom and 10% panic, together with the equally banal comparison between anaesthesia and the flying of an aeroplane. It is the accompanying large colour photograph

of him engrossed in his newspaper during an operation which can hardly improve public perception of our specialty and its professionalism. This, I suggest, brings the profession in general and anaesthesia in particular into disrepute, which is something we hardly need in the current climate of escalating malpractice claims and increasing public scrutiny of consultant's professional behaviour.

To quote Professor Rosen, President of the Association, as published in *Anaesthesia* (1988; 43: 721) '... Reading or listening to tapes during the conduct of anaesthesia distracts the anaesthetist's attention ... If an anaesthetist's regular attitude to work is that it is boring, then counselling is indicated.'

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Teaching laryngoscopy

Dr Williamson (*Anaesthesia* 1988; 43: 424) is correct to draw attention to the difficulty with systems^{1,2} of grading laryngoscopy, and I agree with his conclusion that insufficient attention is given to teaching laryngoscopy and intubation. My communications with many anaesthetists in five continents show, however, that neither of these gradings is yet widely adopted. Difficult intubation should not come as a surprise during an anaesthetic list because the likelihood of its occurrence can be predicted.³

Rigid laryngoscopes fail when the larynx cannot be demonstrated or when there is insufficient room for the anaesthetist to manipulate a tracheal tube or intubating bougie into the larynx. Attempts to intubate under difficulty may be traumatic (e.g. nasal intubation can cause epistaxis and repeated attempts at blind oral intubation can produce laryngeal oedema).

The angulated laryngoscope⁴ referred to by Dr Williamson (and marketed as the 'Belscope') was designed to facilitate otherwise difficult intubation. It frequently has displayed the larynx where the Macintosh blade displayed only the tip of the epiglottis (Samsoon and Young Grade III).² There are no reports yet of its use in the very rare case where the Macintosh does not even display the epiglottis (Cormack and Lehane Grade IV),¹ but it is expected to reveal the larynx in a substantial proportion of these cases, as it has more 'bend' and a lower profile than the Macintosh, and permits rapid attachment of a prism when necessary to see around a blind corner.

Advice on whether to start or persist with the Macintosh laryngoscope at attempts at tracheal intubation in Grade III² or Grade IV¹ difficulty must be relative rather than absolute. This advice is contingent upon the skill of the endoscopist, his or her understanding of the risks of trauma, the likelihood of oesophageal reflux and the maintenance of oxygenation, anaesthesia and relaxation. It also depends on the necessity for immediate intubation as against waking the patient and rescheduling surgery with the benefit of other laryngoscopic equipment and personnel.

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The use of morphine in the intensive care unit

Intravenous morphine is used extensively in the intensive care unit for pain relief¹ and sedation for patients who receive controlled ventilation. Drug tolerance, haemodynamic changes, ileus and bronchospasm are common disadvantages associated with its use. Epidural morphine has become increasingly popular for postoperative analgesia. This method provides effective and uniform analgesia and sedation lasting several hours and avoids the side effects of intravenous morphine. We compared epidural morphine and intravenous morphine in ICU patients who had extensive surgery and required postoperative controlled ventilation of the lungs.

Twenty-nine ASA 3-4 patients were admitted to the ICU after major cancer surgery that involved pelvic, abdominal or thoraco-abdominal malignancies. All patients had previous cardiac pulmonary problems and required postoper-

ative controlled ventilation. Lumbar epidural catheters were placed postoperatively in 14 patients, while 15 received intravenous morphine for pain control and sedation.

In the epidural group, patients received 5-15 mg of morphine and those who had intravenous morphine required 30-100 mg in 24 hours. One-third of the patients who received intravenous morphine were judged to have adequate analgesia and sedation, in contrast to all the patients in the epidural group. Haemodynamic changes were minimal in the epidural group compared to the intravenous group. The incidence of bronchospasm and ileus was significantly less in the epidural group. Sixty percent of patients in the epidural group had elevated P_{CO_2} levels (0.7-1.3 kPa above baseline) with intermittent mandatory ventilation. This was not important since there were no clinical effects of this hypercapnoea such as tachypnoea, tachycardia, hypertension

or alteration in the levels of consciousness. These levels returned to baseline within 24–72 hours after the dose of epidural morphine. The tracheas of six patients were extubated when the patients satisfied other extubation criteria despite elevated PCO_2 levels.

In our study, epidural morphine provided adequate analgesia with significantly less haemodynamic disturbance and minimal incidence of ileus when compared to intravenous morphine. One-third of the intravenous morphine group had adequate analgesia and sedation. Epidural morphine is superior to intravenous morphine for analgesia in patients with compromised cardiac or pulmonary status and who require postoperative controlled ventilation.

Which intravenous induction agent for day surgery?

In the summary to the above article (*Anaesthesia* 1988; 43: 365–8), the authors emphasise the superiority of thiopentone and propofol both at induction and during recovery, and then state that 'this study has altered clinical practice in our Day Surgery Unit'. I was intrigued to find out in what way this lack of difference between thiopentone and propofol had altered clinical practice, and was very surprised to find that they had changed to propofol as the agent of choice for day surgery.

The only demonstrated advantage of propofol over thiopentone which was reported in this study, is the better immediate recovery time. On the basis of this, I would have considered that thiopentone was the agent of choice, in view of the high cost of propofol. There will inevitably be increased drug expenditure if propofol were to replace thiopentone for daycase surgery, unless a larger proportion of patients who have surgery are treated as day cases. Only if this is the case, would it be true that 'the saving (of using thiopentone) is minimal when the overall cost-effectiveness of daycase surgery is taken into account'. Drug expenditure will obviously increase if the number of patients who have surgery as day cases remains constant.

Most hospitals have a Pharmacy Committee, and these committees are already struggling with the problems of overspent budgets. It is, therefore, necessary to be reasonably certain that increased drug expenditure is justified. It may well be that, as the authors point out, a study of 24-hour recovery would show a difference between propofol and thiopentone, but on the basis of the results of this study as given in their report, there appears to be no reason to use the more expensive drug, with thiopentone showing as acceptable a profile on both induction and recovery as propofol.

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A reply

Thank you for the opportunity to reply to Dr Dodson's pertinent comments. The cost of anaesthetic drugs is especially relevant in the current financial climate. Scrutiny of the annual pharmacy bill at Addenbrooke's Hospital reveals that anaesthetic drug costs are low in comparison with the expense of antibiotics and chemotherapeutic agents.

The summary of our publication may have confused Dr Dodson. Methohexitone was my choice for daycase intravenous induction agent for years but after the high incidence of sequelae with methohexitone recorded in the study I have changed to propofol. The high systemic clearance of propofol with no active metabolites makes it an ideal daycase anaesthetic; thiopentone is still used for inpatient anaesthesia.

Common sense should prevail in any attempt to reduce costs. Consultant anaesthetists in a teaching hospital should surely be free to evaluate and use alternative new drugs. A total intravenous anaesthetic technique of alfentanil, propofol and oxygen for gynaecological day cases is now being used. The data at present suggest that there is no prolongation of recovery when propofol is administered by continuous infusion rather than by intermittent bolus. Dr Dodson will therefore note that all inhalational anaesthetic agents are excluded, thereby reducing costs. It would appear that both of us are agreed but we tackle the question of anaesthetic costs from different angles.

Finally, I have the impression that day surgery facilities will expand if NHS resources remain inadequate. A recently completed study on the costs of a 12-bedded day unit with an accountant shows that daycase surgery is cost effective especially if in-patient beds are simultaneously reduced. The savings made by the replacement of propofol with thiopentone would make a minimal contribution.

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Severe coagulopathy in Jehovah's witness

We read with considerable interest the case report by Lockwood *et al.* (*Anaesthesia* 1988; 43: 391–3) in which they attribute an acquired coagulopathy in a 13-year-old Jehovah's witness to transfusion with hydroxyethyl starch (HES).

We recently managed a previously fit, 25-year-old, 72-kg Jehovah's witness who had undergone emergency abdominal hysterectomy after severe uncontrolled post partum haemorrhage. Initially, she refused transfusion with blood or blood products. She received 7 litres HES, 2 litres of polygeline (Haemaccel) and 2.1 litres of 0.9% saline over a period of 17 hours in order to maintain an adequate circulat-

ing volume, as judged by pulse, blood pressure and central venous pressure and urine output. This infusion maintained her haemodynamic function to near normal. She did not become hypotensive during the whole period from the start of her haemorrhage. Her haemoglobin decreased from 3.4 gm/100 ml to 1.2 gm/100 ml during her early postoperative (and untransfused) course in the Intensive Therapy Unit (ITU).

Her clotting profile, measured on admission to the ITU, showed a prothrombin time of 25 seconds (ratio 1.7) with a kaolin cephalin time (KCCT) of 79 seconds (control 40 seconds). Her platelet count was $157 \times 10^9/\text{litre}$. She

agreed to blood transfusion after 17 hours. (We convinced her husband who persuaded her.) Just before the blood transfusion her prothrombin time was 17 seconds (ratio 1.1) with a KCCT of 43 seconds (control 40 seconds). She had received a total of 30 mg vitamin K. Her platelet count was $109 \times 10^9/\text{litre}$. Her ionised calcium was 0.92 mmol/litre. She did not show any clinical evidence of abnormal bleeding (bruising or petechiae [either spontaneous or beyond or below a Dinamap cuff]). She received 11 units of blood and 3 units of fresh frozen plasma over the next 50 hours. Her clotting profile remained normal during this later period, although her platelet count fell to $85 \times 10^9/\text{litre}$ 4 hours after the start of blood transfusion. The platelet count returned towards normal after a further 4 hours.

Her liver function (other than an initial change in prothrombin time) did not appear deranged during her whole stay in the ITU.

We consider that the acquired coagulopathy following HES should not be viewed solely as a consequence of high volume HES (or any other macromolecular) infusion and that the effect observed might have been idiosyncratic. Our patient received the equivalent of 6.8 g/kg HES, which is considerably more than the 2.66 g/kg received by the child. Both these volumes exceed the recommended maximum transfusion volume of 1.2 g/kg (equivalent to 20 ml/kg [Data Sheet Compendium 1988-89]). We should have expected at least a dilutional coagulopathy. Lockwood *et al.* give no details of the anaesthetic technique involved or the level of hypotension, which might have an effect upon liver function. Furthermore, they give no details of coagulation function before 26 hours after surgery.

We believe that HES should remain a primary oncotic solution for resuscitation of such patients, and that the lesson to be drawn is the necessity of checking coagulation profiles during massive transfusion.

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A reply

The letter by Panchal *et al.* gives clinical details of a Jehovah's witness patient who received 7 litres of hydroxyethyl starch (HES) along with other fluids over a 17-hour period. The patient developed a prolonged prothrombin time and kaolin cephalin time, a modest decrease in platelet count but no excessive clinical bleeding. The reasons for these haemostatic changes were not further investigated and any interpretation are thus conjecture. Undoubtedly, some dilu-

tional effect on coagulation factor levels and on the circulating platelet count occurred. For example, the platelet count typically decreases to approximately $100 \times 10^9/\text{litre}$ after the infusion of 7 to 10 litres of stored blood, plasma, crystalloid and colloid.¹

However, in addition, there have now been several case reports²⁻⁴ that HES in addition to causing a dilutional effect may, when volumes above 2 litres are infused, cause a more profound lengthening of the activated partial thromboplastin time (equivalent to the kaolin cephalin time) and a prolonged bleeding time associated with platelet dysfunction.

Our case report further highlights this problem and the associated acquired von Willebrand's type of defect. Du Pont Critical Care in the United States recognise this complication and have recently received nine clinical reports over the previous year of clinical bleeding episodes associated with large repeated infusions of HES.⁵ We thus do not view the changes we reported as an idiosyncratic response but a definite complication associated with the clinical use of large volume infusions of HES. The liver function tests in our patient remained within normal limits throughout and the coagulation tests were all completely normal 2 weeks after her operation. Unfortunately, no samples were taken for laboratory coagulation studies before the development of excessive postoperative bleeding. In future, we would consider the therapeutic use of synthetic vasopressin analogue DDAVP to correct the von Willebrand factor and platelet abnormalities after large infusions of HES in patients, such as Jehovah's witnesses, who refuse the transfusion of whole blood and blood products when haemostatic defects cause an excessive bleeding diathesis.

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Bilateral pneumothoraces after removal of a thyroglossal cyst

A 5-year-old boy, whom we anaesthetised for removal of a thyroglossal cyst, developed surgical emphysema and bilateral pneumothoraces a few hours after the operation. The trachea was intubated with an uncuffed tracheal tube and the lungs ventilated to peak inflation pressures of 2.0 kPa during the procedure. End-tidal carbon-dioxide, haemoglobin saturation, pulse rate and blood pressure were monitored and the fluctuations recorded were unremarkable.

The surgical emphysema that developed after operation involved the head, neck and upper thorax. Respiratory distress was minimal with no signs of upper respiratory tract obstruction despite the extent of the swelling. A chest X ray showed bilateral pneumothoraces; the left lung was completely collapsed.

Oxygen was administered through a facemask and bi-

lateral chest drains inserted under local anaesthesia. Initially a large amount of air escaped into the underwater drainage systems and both lungs re-expanded rapidly. No further air leak was noted and the drains were removed 3 days later.

Bilateral pneumothoraces have not to our knowledge previously been reported as a complication after this operation. However, traumatic tracheal perforation causing bilateral pneumothoraces has been recorded.¹ We consider that the air leak in our patient resulted from perforation of the trachea during a difficult part of the dissection around the thyroid cartilage. Other possible causes and routes of air leak were also considered. Tracheal perforation is a known complication of tracheal intubation itself, but is usually associated with the use of a stilette, inflation of a cuff,² or passage of a double lumen tube.³ Use of excessive

inflation pressures during intermittent positive pressure ventilation could produce barotrauma and bilateral pleural air leak, but in this situation cardiovascular instability from the resulting tension pneumothorax would be expected and this did not occur.

Bronchoscopy was not considered necessary in this case since the patient's condition improved rapidly with the treatment described.

This case emphasises that a major complication may follow an apparently straightforward operation in the area of the trachea. Vigilance is required in order that such a complication is recognised and treated promptly.

Humidification and CPAP systems

The need for warm humidification of gases in respiratory care is well established. Continuous positive airways pressure (CPAP) systems are a standard form of therapy in intensive care units and flow generators are available which can provide a high enough gas flow to remove the need for a reservoir bag in the system. The manufacturers of the C.C.P.A.P. high flow system (Medic-Aid Ltd.) state that a flow in excess of 100 litres/minute may be used. It is not possible, however, to raise the temperature of the inspired gases adequately, at these flow rates using standard humidifiers.

Three humidifiers in common use, Bennett Cascade, Drager Aquaflo and the Cape heated-water bath were

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tested. Temperature and humidity were measured at a point 2 m distal to the humidifier. The maximum temperature measured was 31.2°C with a relative humidity of 90% at a flow rate of 100 litres/minute. A temperature of 35°C with a relative humidity of 90% could be achieved at flow rates less than 60 litres/minute.

When humidification is important, a CPAP system which incorporates a reservoir bag, and therefore uses lower flow rates, should be selected.

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The nasocardiac reflex

We read the case report by Drs Baxandall and Thorn on the nasocardiac reflex with interest (*Anaesthesia* 1988; 43: 480-1). The degree and nature of the cardiorespiratory reflexes initiated by the nose are species dependent. Some may be a modification of the submersion reflex seen in aquatic animals, and present in man, preventing water entering the airway.

Nasal irritation in general may cause apnoea, laryngeal closure, bradycardia and variable changes in blood pressure.¹ Bradycardia and vasovagal symptoms are frequently seen in the ENT outpatients department in patients who have nasal instrumentation. They are mediated by both the sympathetic and vagus nerves and may be obtunded by local anaesthesia of the trigeminal nerve or more conveniently, topical anaesthesia of the nasal mucosa. Such reflexes are unusual under general anaesthesia but may account for the significant bradycardias found in three patients in the study of Bromley and Hayward.²

There was no pre-operative preparation of the nose in the case reported. Cocaine solution (5-10%) provides useful anaesthesia and vasoconstriction. Cocaine potentiates endogenous catecholamines both centrally and peripherally by blocking the reuptake of noradrenaline. This may lead to tachyarrhythmias, particularly in the presence of halothane anaesthesia. However systemic absorption can be limited by the addition of adrenaline to the solution² with additional useful vasoconstriction. Whether topical preparation of the nose would have prevented such a profound bradycardia or not, this case highlights yet again the value of monitoring in the anaesthetic room when nasal intubation or manipulation is performed.

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Drs Baxandall and Thorn's case report on the nasocardiac reflex (*Anaesthesia* 1988; 43: 480-1) refers to the parasympathetic nerve supply to the nose as of vagal origin. This is not the case. The preganglionic parasympathetic fibres arise from the superior salivary nucleus in the pons. They are carried to the sphenopalatine ganglion through the nervus intermedius (vll) and then the greater superficial petrosal and vidian nerves.

My similar experience to that of the authors' occurred at the beginning of a nasal polypectomy: the insertion of a nasal speculum produced an immediate marked bradycardia with profound hypotension. Cardiac massage and inotropic support were required to stabilise the patient and the procedure was abandoned. This patient's nose had been painted with 25% cocaine paste 10 minutes before any manipulation, and one would have expected this to produce some local anaesthetic affect as well as the desired vasoconstriction.

A further factor to be taken into account is whether the use of cocaine in this patient contributed to the cardiovascular collapse because of a hypersensitivity reaction. However I would expect such a reaction to be accompanied by a tachycardia rather than the bradycardia which was noted in both patients.

The nasocardiac reflex therefore appears to be potentially, but rarely, of serious clinical importance. The use of local anaesthetic agents to reduce its activity is not necessarily effective and may possibly be contributory to the problem. The parasympathetic supply to the nose is really a derivative of the facial nerve rather than the vagus and thus the reflex is unlikely to be purely vagal in nature.

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Paralytic ileus during ketamine infusion

We report a case in which a profound paralytic ileus developed in a patient who was treated for severe bronchospasm with a ketamine infusion.

The patient, a 58-year-old man who weighed 80 kg, was admitted to the intensive care unit with a 5-day history of increasing dyspnoea and wheeze. He had a history of chronic obstructive airways disease. Initially, he was treated with aminophylline, steroids and inhaled bronchodilators and antibiotic therapy was started. He became progressively more breathless despite this treatment with a widespread wheeze over both lung fields. His trachea was intubated and his lungs mechanically ventilated.

Ventilation became progressively more difficult despite maximum doses of intravenous aminophylline and bronchodilators and a ketamine infusion was started at a dose of 1 mg/kg/hour after an initial intravenous bolus of 50 mg. A nasogastric tube was inserted. The bronchospasm began to decrease, with a consequent reduction of inflation pressures and an improvement in his blood gases. He was sedated with lorazepam 2 mg twice a day in addition to the ketamine infusion. He did not receive any muscle relaxants or opiates.

Four hours after the infusion was started the volume of his gastric aspirate increased to 100 ml/hour. Bowel sounds had ceased. Urea and electrolytes were within normal limits as were his liver function tests and blood glucose. His abdomen became distended and tympanic.

His chest had improved by the third day but his abdominal distension made spontaneous breathing difficult and controlled ventilation could not be discontinued. The keta-

mine infusion, which had been progressively reduced was now turned off. Bowel sounds rapidly returned with a reduction in nasogastric aspirate and flatus was passed. Weaning from the ventilator proceeded uneventfully and he was discharged from ITU 2 days later.

Previous reports of the use of continuous infusion of ketamine to treat bronchospasm^{1,2} do not mention any gastrointestinal effects of this treatment. The fact that the ileus responded so quickly to the withdrawal of the infusion indicates that this was the cause. The patient took oral fluids until ventilation was started and he began to absorb fluids again before ventilation was stopped.

We conclude that if ketamine infusions are used for the treatment of refractory bronchospasm, the dose should be reduced and the infusion stopped before weaning is attempted.

This reaction was reported to the Committee on Safety of Medicines.

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Subarachnoid spread of epidural local anaesthetic following dural puncture

The paper (*Anaesthesia* 1988; **43**: 671-4) by Drs A. Leach and G.B. Smith was interesting and I congratulate them for leaving the epidural catheter *in situ* for subsequent radiological proof of its position. Too often the catheter is removed and endless discussion on the various possibilities of malposition follows.

Could I suggest what I believe is a more rational approach to an inadvertent, but easily diagnosed, dural tap? Rather than remove the needle and insert a catheter at an adjacent space, why not leave the needle where it is and insert a subarachnoid catheter? At least you know where it is and that all the local anaesthetic you inject is going into the subarachnoid space, not a variable and unknown amount as was the case with Drs Leach and Smith's patient.

For relief of pain in labour 1-3 ml plain bupivacaine 0.5% or 1-1.5 ml of hyperbaric bupivacaine will be sufficient. Subsequent top-ups can be adjusted appropriately once the area of the spinal blockade has been mapped out.

Continuous spinal anaesthesia is becoming more popular worldwide and one surprising fact that has emerged from its use is the relative rarity of postspinal headache.¹ The reason why the insertion of a catheter through a dural hole made by an 18-gauge epidural needle should lessen the incidence of headache is not immediately obvious, but the article by Dittman *et al.* may offer some clues.²

In any event, once the hole has been made it seems better to make a virtue of necessity and convert to a continuous spinal technique. It will at least save the mother further discomfort (of some importance in the reported case who had four more 'needlings' after the dural tap) and the

position of the catheter reaching the subarachnoid space, will not be in doubt.

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A reply

The comments concerning our paper are most welcome and I agree that, as we gain more experience in the use of continuous spinal anaesthesia, its use after dural puncture in labour would be a logical approach. It will be interesting to see what the incidence of postdural puncture headache is in the younger age group of obstetric patients if this technique is adopted.

Our reluctance to use continuous spinal anaesthesia in the past is probably not only a result of our lack of experience in this technique but also from fears of the introduction of infection into the cerebrospinal fluid (CSF). If one thinks about this logically, once a dural tap has occurred CSF is also present within the epidural space and we have had no hesitation in passing epidural catheters in these cir-

cumstances. Our paper also demonstrates that, when a dural tap has occurred, not only will CSF pass from the subarachnoid into the epidural space but contrast will pass in the opposite direction and, presumably infection could also.

Therefore, in these circumstances, is continuous spinal

anaesthesia any more hazardous than continuous epidural anaesthesia?

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Postoperative inspiratory stridor

An excellent description of a common postoperative problem is given in Dr Margary's letter (*Anaesthesia* 1988; 43: 607). The features are: a fairly short procedure under relaxant anaesthesia with minimal supplementation; apparently satisfactory reversal and tracheal extubation; an inspiratory stridor which starts a few minutes later when the patient is conscious, and which increases as he becomes more and more agitated; and relief after a small intravenous dose of a benzodiazepine (Diazemuls 1–2 mg).

It is misleading, however, to describe these episodes as laryngospasm. In my first case light anaesthesia with halothane was reintroduced and the patient began to breathe freely, the cords were moving normally, and there were none of the anticipated pharyngeal secretions.

The most significant characteristic of this stridor is that it is inspiratory; expiration is free, if sufficient air can be inhaled. It seems to me that the mechanism of the obstruction is akin to that in tracheomalacia. The muscle tone in the supralaryngeal area is inadequate to ensure a patent airway, and as the patient rouses and becomes agitated and his inspiratory efforts increase, the airway collapses. This

initiates a vicious circle of increasing agitation and obstruction. Minimal sedation reduces the subatmospheric inspiratory pressure to a level the supraglottic airway can tolerate.

This condition occurs about twice a year in our recovery room and I have discussed it with many colleagues, yet there is not a good description of it in any account of the minor complications of anaesthesia. It is important because it is a distressing event which the patient remembers ('I couldn't get my breath when I woke up'), and because it is so easily alleviated without recourse to suxamethonium and reintubation.

May I suggest that it is also an example of the need to differentiate clearly between description of an observation (*inspiratory stridor*) and imputation of a mechanism (*laryngospasm*). Similar confusion can occur when wheezing is described as bronchospasm. Imprecise terminology may lead to the wrong treatment.

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F.L. ASHWORTH

Inadvertent epidural midazolam and fentanyl

We would like to report a case of inadvertent infusion of midazolam and fentanyl through the epidural route and the reversal of systemic side effects with flumazenil and naloxone.

A 70-year-old woman was involved in a car accident, and sustained multiple injuries, including a ruptured spleen, multiple rib fractures with pneumothorax and a head injury.

She was admitted after laparotomy to the intensive care unit, her lungs were ventilated and she was sedated with an infusion of midazolam and fentanyl. Early weaning was instituted, and at this time a thoracic epidural at T_{8/9} was sited. An infusion of bupivacaine 0.125% was started and the intravenous midazolam and fentanyl withdrawn. She was gradually weaned from ventilation over the course of the next 4 days, until she was maintaining adequate blood gases on spontaneous breathing. She became progressively sedated to the point of unconsciousness on the fifth day. Her respiratory rate decreased from 14/minute to 6/minute over 45 minutes; blood gases deteriorated and a sustained decrease in arterial blood pressure, which was unresponsive to fluids, was noted. No immediate cause was found but it was noted that the initial midazolam and fentanyl infusion had been connected to the epidural catheter erroneously in place of bupivacaine. The infusion consisted of midazolam 20 mg, fentanyl 300 µg and 40 ml normal saline. This had been infused at a rate of 3 ml/hour for approximately 2 hours (1.2 mg midazolam/hour i.e. 2.4 mg).

Naloxone 0.4 mg was administered intravenously once the cause of her condition became apparent. Her respiratory rate increased, but she remained hypotensive and unresponsive to pain. A total of 1 mg flumazenil was therefore administered, with a subsequent rapid awakening and sustained increase in blood pressure.

The effects of intrathecal midazolam (0.5–1.0 mg) were studied in dogs; no systemic side effects and no effects on the cardiovascular system were observed.¹ Reversal of local effects was achieved with Ro15-3505 in this study. Midazolam epidurally however, appeared to have marked systemic side effects that included profound sedation and probably hypotension. The fentanyl clearly may have contributed to these effects, but reversal was incomplete after naloxone alone. This suggests that other effects were either the result of systemic absorption of midazolam or of a species difference in epidural effects of midazolam between dogs and man. We have seen hypotensive effects with systemic midazolam in intensive care patients but the dose administered was fairly small under normal circumstances.

We know of no other case of epidurally administered midazolam in man or of human studies related to this, so it is not possible to be definite whether the effects were systemic or epidural. Whichever mechanism was responsible we considered it important to report that flumazenil was successful in reversing the effects.

Our patient made a full recovery from this incident, and indeed from her original trauma, with no apparent sequelae attributable to this epidural infusion, and we were able to avoid reventilation by the use of flumazenil.

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Antiemetics for patients with malignant hyperthermia

In the case report by Dr E.R. Emmanuel (*Anaesthesia* 1988; 43: 666–70) on anaesthetics for malignant hyperthermia he correctly states that butyrophenones should not be used in MH susceptible patients since these drugs can cause an idiosyncratic response. However, in the last anaesthetic given to his patient he gives 5 mg of droperidol at the end of anaesthesia; droperidol is the classic butyrophenone that can cause the neurolept malignant syndrome.

This is, in my opinion, a grave error in view of the fact that this paper is supposed to illustrate the ideal management of an MH susceptible patient.

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M.E. SINCLAIR

A reply

Thank you for the opportunity to reply to Dr M.E. Sinclair, who draws attention to my omission of the circumstances in which droperidol was used in the immediate period after anaesthesia on two occasions.

However, I must first remind your readers that I do not claim that the anaesthetic management described is the absolute ideal for malignant hyperthermia susceptible (MHS) patients.

The grave error belies a perhaps controversial but deliberate decision taken with due regard to the contemporary knowledge about MH. Nausea, probably induced by the intra-operative narcotics, which occurred on emergence from anaesthetics 7 and 9, had to be swiftly terminated in order to stop the occurrence of vomiting. Three groups of drugs were available: phenothiazines; metoclopramide: this is not a phenothiazine and its effect on MHS patients is not widely known, but it can cause dystonic reactions like the phenothiazines;¹ butyrophenones: reports of idiosyncratic response to these drugs were then few and related to haloperidol taken over a period of time.

So, after anaesthetic number 7, the decision was taken to use a small dose of droperidol and, since no ill-effect occurred, this was also repeated after number 9. This drug is stated not to be a trigger of acute MH.²

The idiosyncratic response to psychoactive drugs (basically the dopamine receptor blocking drugs and catecholamine depleters)³ is now known as the neurolept-malignant syndrome (NMS). It resembles MH but is not thought to be closely related.⁴ The disturbed mechanisms are in the central nervous system, and it is believed that this is the site of action of the triggering drugs (whereas in MH the disturbed mechanisms are situated peripherally, in skeletal muscle). Haloperidol can trigger this syndrome and perhaps should not be given to those MHS subjects with a psychiatric indication; but the related drug, droperidol appears to be safe in MHS people.²

Thus with regard to the question of a safe antiemetic for MHS subjects, the following drugs should be considered: cyclizine, which belongs to the piperazine group of drugs; metoclopramide, which after all, is not a phenothiazine; droperidol; and perhaps nabilone, a synthetic cannabinoid.

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Multiple anaesthetics for a malignant hyperthermia susceptible patient

The report by Dr E.R. Emmanuel (*Anaesthesia* 1988; 43: 666–70) illustrates one of the problems with regard to malignant hyperthermia (MH) in that patients with positive muscle biopsy contracture tests can have general anaesthetics which involves known triggering agents without developing clinical MH.

The basic problem in the full blown MH syndrome is excess heat in the body tissues, and therefore anything which predisposes to increased heat production or decreased heat loss would increase the liability to develop clinical MH. This could involve changes in intracerebral neurochemistry, e.g. in response to a cold environment, or peripheral factors, or intracerebral neurochemical changes may produce peripheral changes which may incidentally alter heat balance. These mechanisms can be seen in some of the factors known to increase the risk of developing MH.¹

There is already an increased heat content of the body if a patient is feverish and the cerebral control of temperature has been distorted.

Stress, apprehension, pre-operative trauma and post-operative pain¹ are all associated with alterations in intracerebral neurochemistry with secondary increases in the peripheral circulating levels of adrenaline, noradrenaline and cortisol which all increase heat production and (or)

decrease heat loss.² Muscles are warmed up after violent exercise¹ and cell metabolism is geared to increased energy production which is totally diverted to heat production after stopping the exercise. Similarly, in virtually all the other factors known or suspected of an association with an increased risk of MH¹ it is possible to identify a peripheral, a central neurochemical and (or) a peripheral catecholamine mechanism which tends to increase body heat. For the full-blown clinical MH syndrome to develop it may therefore require an MH susceptible person, plus more than one provoking factor which may or may not include exposure to anaesthetic triggering agents.

Incidentally, Dr Emmanuel still refers to ice as one of the requirements for treating MH. Ice on the skin is counterproductive since it will not only produce vasoconstriction but also stimulates heat production including shivering. In fact the stress of a sudden change from very high to very low temperatures has been known itself to trigger MH.¹ We can learn from the treatment of heat-stroke in which ice was also used in the past. Ice is now not used since it is harmful, and cooling is performed by spraying the patient with warm water, to encourage vasodilatation, and blowing warm air over the patient to cool by evaporation.³ This is far more efficient than ice

in cooling patients with heatstroke and would probably be equally effective in MH.

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A reply

It was not intended to discuss the aetiology of acute malignant hyperthermia in the report, but it is pleasing to see the interest that has been generated. Thus the report only made brief mention of stress; and the factors to which Dr E.L. Lloyd refers are well documented in the various reviews of this subject. These include the possible triggering of acute malignant hyperthermia (MH) in an MH susceptible (MHS) subject by intrinsic or extrinsic heat; but it must be remembered that the heat of exercise does not seem to increase the predisposition of MHS individuals to acute MH.¹ Exercise-induced heatstroke and acute MH have many similarities but do not appear to be linked²; nor is this mentioned in a recent review.³

The correct definition of MH 'is a pharmacogenetic disorder characterised by acute hypercatabolic reaction in muscles in response to the triggering effects of certain drugs (used mainly in anaesthesia) and stress'³ (Dr Lloyd states 'may not include exposure to anaesthetic triggering agents').

The basic problem in acute MH is disordered skeletal

muscle metabolism; and present treatment is aimed at restoring this to normal. The excessive heat production that occurs is secondary; and it could be that external methods of encouraging heat loss when dantrolene is used, may no longer be paramount.

Lastly, the very brief mention of ice in the report is wrongly construed to mean dermal application; wind tunnel cooling using a sheet dampened with ice-cold water is the preferred method, after personal successful management of an acute MH episode many years ago. One review advises the use of an ice-cold water bath in certain circumstances.³ Naturally, temperature change must not be sudden and must be carefully monitored.

Dr Lloyd's reference to warm water with warm air cooling, is rational; but it seems to me that very warm water would be required to encourage good vasodilatation and together with warm air might not have the desired effect.

Pharmacological vasodilatation might be more efficient, carefully using an MH inert drug, for example verapamil² and (or) glyceryl trinitrate, and blowing air at 15°C-20°C; but use of these drugs could pose other problems.

So, since the use of dantrolene, it could now be that external methods of increasing heat loss in acute MH may no longer be of importance in the majority of cases.

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Perioperative dreaming in children

The article by Drs O'Sullivan, Childs and Bush (*Anaesthesia* 1988; 43: 104-6) about this subject was interesting.

Their theory about arousal as a result of increased muscle spindle discharge with increments of suxamethonium is not questioned but their conclusion is.

Fifty-eight patients in the study received an anaesthetic technique which included no premedication, and maintenance of anaesthesia was with 70% nitrous oxide in oxygen and suxamethonium increments.

An anaesthetic technique identical to the aforementioned in women undergoing Caesarean section carries an incidence of 10% awareness.¹ Seeing that MAC is higher in children² this technique could reasonably be expected to yield the same, if not higher, incidence of awareness in children.

In the study by McKie and Thorpe³ from which the postoperative questionnaire was constructed, they found a 5% incidence of true awareness, and the majority of these cases had received nitrous oxide/oxygen/relaxant-type anaesthesia. Furthermore, the study does not differentiate between pleasant and unpleasant dreams. Wilson and Turner¹ state that unpleasant dreams are more likely to lead to psychological trauma, and that the prevention of these recollections would benefit the patient.

In view of these findings, it would be very surprising if a significant proportion of children in the study had not been aware or had had unpleasant dreams.

In today's practice, a general anaesthetic technique for Caesarean section with a 10% incidence of awareness would be considered indefensible in a court of law. Children are unlikely to be litigation-minded themselves but surely they deserve the same consideration of amnesia for the duration of their operative procedures?

The conclusion of the study should be to give these children an adequate anaesthetic rather than pretreat them with non-depolarising muscle relaxants.

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We found the report by O'Sullivan *et al.* (*Anaesthesia* 1988; 43: 104-6) interesting but disturbing. Their technique of profound muscular paralysis, hyperventilation and nitrous

oxide anaesthesia was associated with a minimum incidence of dreaming of nearly 3%, which seems high, and suggests to us that there is a risk of awareness with this technique, a risk which may well be greater in the hands of occasional paediatric anaesthetists such as ourselves.

The Medical Defence Union has made it clear that awareness under general anaesthesia is indefensible,¹ but even if awareness is not complained of, such light levels of anaesthesia may not be in the patient's best interests. Anand *et al.*^{2,3} have recently reported on the effect of adding a volatile anaesthetic agent and an analgesic to the traditional very light anaesthesia given to neonates. Their work suggests that not only is the stress response alleviated in terms of metabolic indices but that the postoperative clinical course is improved. It is reasonable to suppose that older groups may also benefit.

It has been shown that low concentrations (one MAC equivalent) of volatile anaesthetic agents reliably abolish the auditory evoked response^{4,5} and since the auditory cortex is the most metabolically active part of the brain we presume that this guarantees unconsciousness. The anaesthetist now has a reasonable choice of such agents and we consider that there can be few occasions when such a small addition is impossible.

Perhaps we could respectfully remind Dr O'Sullivan and colleagues of the work of the founders of the 'Liverpool school'⁶ who stated in 1946 that 'Curare is not an anaesthetic'.

We suggest that the occurrence of dreaming associated with very light anaesthesia is better treated by turning on the vaporizer than giving curare.

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A reply

Thank you for giving us the opportunity to reply to the letters from Dr Guise and Drs Robinson and Calder.

Dr Guise mentions the study by Wilson and Turner of women who undergo Caesarean section.¹ The incidence of factual recall in this study was 2% and not 10%. The anaesthetic technique was not identical to ours: 70% of patients received less than 75% nitrous oxide, whilst all our patients had 70% nitrous oxide.

McKie and Thorpe² who studied 202 children, reported a 5% incidence of factual recall. We do not consider our results to be comparable with theirs since all the patients in our study were undergoing minor procedures as day cases.

The range of surgical procedures varied from open heart to neurosurgery in the McKie and Thorpe study. Of their 10 patients studied who had factual recall, two had been anaesthetised using a technique with spontaneous ventilation, and a further four had controlled ventilation with a relaxant technique which included halothane. The remaining four had received a premedication which consisted of papaveretum and hyoscine. Furthermore the parameters of controlled ventilation were not stated.

Fourteen patients reported dreaming in our study: 10 had pleasant or nice dreams compared with four children who had unpleasant dreams. None of the children was in any way disturbed by the dreams. It is interesting to note that nine of the children who reported dreaming indicated that they dreamt often at home.

The work published by Anand *et al.*^{3,4} though extremely interesting refers to the modification, by anaesthetic agents, of the stress response which we believe is of a different order to that required to eliminate awareness.

We are also well aware that 'curare is not an anaesthetic'. However, the suggestion that 'turning on the vaporizer' decreases the occurrence of dreaming has not been substantiated by any of the studies done in this field. As already stated, four out of the 10 children who had factual recall in the study by McKie and Thorpe² had a controlled ventilation technique which included halothane. A further two patients who breathed spontaneously, were anaesthetised with halothane and methoxyflurane. Hobbs, Bush and Downham studied a further 41 patients who were anaesthetised using the 'Liverpool technique' with halothane as an initial adjuvant. They found a similar incidence of dreaming of 10% in this group of patients compared with the overall group (12%) (unpublished data).

The recent paper by Hobbs *et al.*⁵ suggests that dreaming results from arousal produced by depolarising drugs and a clear distinction must be drawn between dreaming and factual recall.

It must be reiterated that, as mentioned in our article, no case of awareness was elicited in the patients in our study. Furthermore in the study of Hobbs, Bush and Downham⁵ no patient reported awareness.

We also point out that whilst this technique was used for minor procedures, in all procedures associated with pain the patients receive either a narcotic premedication in major cases, or a local anaesthetic block, or intravenous analgesics when indicated.

Finally, it is our opinion that the children in this study did receive adequate anaesthesia as defined by lack of awareness and conscious appreciation of pain during the procedure.

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Malignant hyperthermia in children

Drs Ginsburg and Purcell-Jones have very rightly drawn attention to the possibility of malignant hyperthermia reactions in small children during anaesthesia (*Anaesthesia* 1988; 43: 386-8). However, to their suggestions for management of such patients, we would like to add the use of end-tidal carbon dioxide monitoring. In our experience, the detection of increased carbon dioxide production has been invaluable in the early diagnosis of malignant hyperthermia: indeed, so much so that we now consider capnography to be the single most important monitor in patients who may be susceptible to malignant hyperthermia, the rise in CO_2 precedes other signs of the onset of malignant hyperthermia. Continuous monitoring of carbon dioxide production is our best guide to dosage requirements for dantrolene crisis in established malignant hyperthermia.

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A reply

We agree. Capnography, if available, can be a useful aid in the diagnosis and management of a malignant hyperthermia crisis. However, we would counsel caution in its use as a sole diagnostic criterion and advise that the data obtained should always be interpreted with reference to the clinical context.

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R. GINSBURG
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Failure to detect disconnection by capnography

There is considerable interest in the minimum monitoring standards required for the safe practice of anaesthesia,¹ and in particular the capnograph, which is recommended as a disconnection alarm.² We wish to report a set of circumstances under which the capnograph fails to act as an anaesthetic system disconnection alarm.

A 9-year-old girl with Down's syndrome was anaesthetised for resection of tracheal stenosis. She weighed 30.2 kg and a Penlon Nuffield 200 ventilator through a Bain's system was used to ventilate her lungs. Fresh gas flow was 7.5 litres/minute with an FIO_2 0.33 and the ventilation delivered a tidal volume of 300 ml at a rate of 15 breaths per minute. The expiratory limb of the system was thus full of the patient's expired gases.

To enable the tracheal anastomosis to be made a 5.0-mm tracheal tube was placed in the distal tracheal opening whilst the sutures were placed in the proximal trachea. The tracheal tube was then removed from the trachea whilst sutures were being placed in the distal trachea (a manoeuvre which lasted about a minute), and 100% oxygen was given before the tube was removed. Use of a pulse oximeter ensured that hypoxia was not allowed. This sequence of events was repeated until the anastomosis was completed.

The ventilator continued to cycle during the periods of disconnection, thus gradually pushing the gas in the expiratory limb of the Bain's system out past the sampling probe of the capnograph, which was situated between the end of the system and the tracheal tube. This was expired gas so it contained carbon dioxide and hence the capnograph continued to read a concentration which fluctuated between zero and 2% and therefore did not alarm.

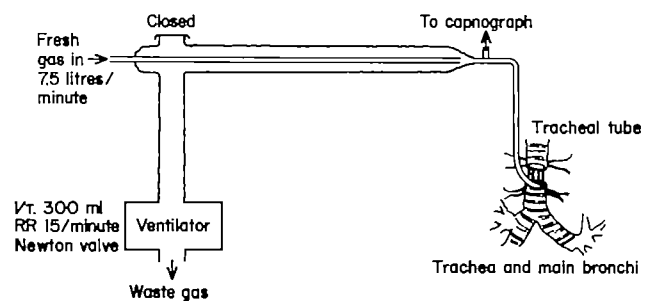


Fig. 1. Diagram of the circuit used for tracheal resection.

We conclude that the use of low flows with the ventilator and system described prevents the capnograph from detecting a disconnection (or extubation) for a period of time greater than one minute and recommend that under these conditions a disconnection alarm that relies on airway pressure measurement is used.

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A new use for the hole in the bag

Monitoring end-tidal CO_2 (and also inspired gases) in children, when the Jackson Rees modification of the T-piece system is used, can be performed using a stiff manometer line. The line is inserted into the open tail end of the 500-ml bag, through the expiratory limb and out of the anglepiece. The tip of the line is located close to the trachea, for example in the Guedel airway or near the tracheal tube. The distal

end is then connected to a gas analyser. The manometer line is fixed to the breathing system ensuring that the hole in the bag is not obstructed. This method reduces the dead space inherent in many other sampling systems.

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T.K. OOI

Epidermolysis bullosa and porphyria

Ketamine dissociative anaesthesia is, as Hagen and Langenberg point out, a safe and well described technique for patients with epidermolysis bullosa dystrophica (*Anaesthesia* 1988; 43: 482-5). However, we take issue with their state-

ment that 'patients are more liable to have porphyria, and barbiturates must be avoided.' Other authors have also suggested an association between epidermolysis bullosa and porphyria,^{1,2} but this has never been substantiated.³ Even

the statement of an association by Katz and Kadis, which is further quoted by other authors, is not supported by references.^{4,5}

It would appear that the association between epidermolysis bullosa and porphyria was first suggested in textbooks of dermatology published in the 1960s.^{6,7} Andrews and Domonkos state, in a section on epidermolysis bullosa, that 'porphyria may be present.' Marshall questions the very existence of epidermolysis bullosa, stating that patients with 'non-porphyrin epidermolysis bullosa' almost always prove subsequently to have porphyria; porphyrin excretion in such patients is within normal limits for prolonged periods. An alternative term at that time for the blistering eruptions induced by trauma in patients with porphyria cutanea tarda was epidermolysis bullosa porphyrica.

These examples illustrate the diagnostic confusion which existed between epidermolysis bullosa and porphyria cutanea tarda. Indeed, the skin lesions may be identical and porphyrin excretion is often normal in patients with porphyria cutanea tarda. But nowadays the two diseases can easily be distinguished on histopathological, immunofluorescence and porphyrin studies.⁸

Thus we contend that there is no evidence of any association between epidermolysis bullosa and porphyria. Porphyria should be considered in the differential diagnosis of epidermolysis bullosa and other blistering disorders, and porphyrin studies should be performed in patients with undiagnosed bullous disease. However it seems unnecessary, and possibly dangerous, to withhold barbiturates from patients with proven epidermolysis bullosa, particularly as these and other drugs likely to induce hepatic porphyrias, appear safe in patients with porphyria cutanea tarda.^{8,9}

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A reply

Barbiturates are not drugs of choice in patients who are in a poor physical condition with low serum protein and compromised liver function. They may give rise to respiratory depression in these patients for whom assisted ventilation using a facemask or tracheal intubation may be required; both these methods should be avoided in patients with epidermolysis bullosa dystrophica.

I am unable to comment on the statement that there is no evidence of any association between EBD and porphyria. Nevertheless there always remains a degree of uncertainty in reaching a differential diagnosis and therefore unnecessary risks appear to be undesirable.

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Anaesthesia for carbon dioxide laser laryngeal surgery in infants

The paper by Hunton and Oswal (*Anaesthesia* 1988; **43**: 394-6) describes a new paediatric metal tracheal tube which provides another method of anaesthesia which reduces or eliminates the risk of fire. However, we disagree that plastic materials such as nasogastric tubes must *never* be used in a patient undergoing carbon dioxide laser surgery.¹

Tracheal intubation severely restricts surgical access during laser surgery for laryngeal papillomatosis in children because the posterior larynx and subglottic region is obscured by the presence of a tracheal tube. They describe a technique of initial tracheal intubation with the Oswal-Hunton tube followed by extubation and venturi injector ventilation through a modified operating laryngoscope.

Our own experience includes over 60 anaesthetics given for laser surgery in small children (age range: 1.8-6.5 years). In all cases we have used a technique of pharyngeal insufflation of gases with spontaneous breathing. Induction of anaesthesia with halothane in oxygen, and establishment of intravenous access, is followed by laryngoscopy and the larynx is sprayed with a metered 10% lignocaine spray up to a maximum dose of 3 mg/kg. A 14-gauge suction catheter with extra holes cut in the distal end is then passed through the nose to lie in the nasopharynx. Oxygen at a flow rate of 4-6 litres/minute and 3-4% halothane are insufflated through the catheter for the maintenance of an-

aesthesia. Great care is taken to ensure that the catheter remains in the nasopharynx and does not encroach on the surgical field. Routine monitoring consists of electrocardiography, noninvasive blood pressure measurement, a precordial stethoscope and pulse oximetry.

This is a simple technique and provides excellent operating conditions since the larynx is not obscured by the presence of a tracheal tube. Laryngeal trauma is minimised and oedema formation may be reduced. Constant vigilance is required to ensure the airway remains patent. Suprasternal recession and thoraco-abdominal paradox are observed during spontaneous breathing in patients with severe airways obstruction. Pulsus paradoxus is also detectable by palpation at the radial pulse. We attach considerable importance to these simple physical signs and, if present, they can be improved by prompt removal of the obstructing lesions with the laser.

As Oswal and Hunton point out no single method of anaesthesia is suitable for every patient. However, their anaesthetic technique seems unnecessarily complicated and may be traumatic. They discuss the hazards of venturi injector ventilation although they do not mention the possible risk of 'seeding' of papillomata into the trachea and bronchial tree when using this method.² Our technique of pharyngeal insufflation through a plastic suction catheter

during spontaneous respiration has proved to be simple and safe and does not involve instrumentation of the larynx with its associated risk of trauma.

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Detection of oesophageal intubation: the cola complication

Dr Wee, in his excellent report¹ on the oesophageal detector device, cites Birmingham *et al.*² who maintain, that the diagnosis of oesophageal intubation can be reliably made in the absence of carbon dioxide in exhaled gas. However, there are several potential causes of delay in the detection of inadvertent oesophageal intubation when carbon dioxide analysers are used. The capnograph gives a false positive reading if carbon dioxide is present in the stomach. Dr Wee mentions one possible source of carbon dioxide in the stomach: the byproduct of prophylactic magnesium trisilicate or sodium bicarbonate which has reacted with gastric acid. This problem has not been reported to date. However, carbon dioxide may be forced into the stomach in substantial amounts during manual ventilation before intubation. After intubation and inadvertent oesophageal tube placement, the resulting carbon dioxide pattern may then resemble the tracing from a correctly placed tube. This phenomenon has been demonstrated experimentally and encountered clinically.^{3,4}

Carbon dioxide may also be present in the stomach of nonfasted patients who present for emergency surgery. We recently anaesthetised a young boy for appendicectomy. The child was pre-oxygenated but the lungs were not ventilated manually before intubation, in accordance with our standard rapid sequence intubation. After intubation, inadvertent oesophageal intubation was readily evident on auscultation of the lungs and epigastrium. Repeat laryngoscopy showed that the tube was in the oesophagus. The carbon dioxide analyser showed a pattern compatible with correct tracheal intubation for the first few breaths. The tube was uneventfully replaced into the trachea. The boy's mother reported, on close questioning, that he had drunk a quantity of a carbonated beverage, before hospital admission.

We thought that this might be the origin of the carbon

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dioxide detected in the stomach. We tested our hypothesis *in vitro* by manual ventilation of a 2.5 litre reservoir bag (representing the stomach) into which we had poured 500 ml of a popular soft drink. The contents were gradually warmed to 37°C in a waterbath. We recorded maximum end-tidal carbon dioxide pressures of 28 mmHg. Similar results could be obtained using a variety of soft drinks.

Previously ingested carbonated beverages may have an effect on end-tidal carbon dioxide level after inadvertent oesophageal tube placement. In countries where soda pop drinking is endemic, evaluation before operation should include assessment of what we would like to call the cola complication. Continued observation of the capnograph after intubation and utilisation of a simple method such as the oesophageal detector device¹ will avoid this pitfall.

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Breathing bag refilling

Placement of the tracheal tube in the oesophagus instead of the trachea can result, if undiagnosed, in a catastrophic outcome. Wee has recently described an oesophageal detector device for the detection of oesophageal intubation.¹ The present report utilises refilling of the breathing bag during manual ventilation as another simple method to distinguish oesophageal from tracheal intubation.

Ten healthy young patients undergoing elective surgery were investigated. Anaesthesia was induced with thiopentone and suxamethonium in all patients. The trachea was intubated under direct vision after oxygenation and the tube cuff was inflated to prevent air leak. The patients' lungs were ventilated with 100% oxygen. The pop-off valve of the anaesthesia system was then closed and the breathing bag filled with oxygen. The oxygen flow from the anaesthesia machine was shut off. A squeeze of the breathing bag by hand resulted in bilateral chest movement as shown by chest auscultation, and was followed by exhalation and rapid bag refilling. Adequate chest inflation could be repeated 3-5 times, despite the continued interruption of the fresh gas flow.

The oesophagus was then intubated with a tracheal tube of the same size as that used for tracheal intubation, and

its cuff was inflated with 5 ml air. The anaesthesia system was then connected to the oesophageal tube. Repeating the same test as described during tracheal intubation showed that bag squeeze did not inflate the chest and was not followed in any of the patients by any significant bag refilling.

Repeated filling and emptying of the stomach during oesophageal intubation, leading to inflation and deflation of the breathing bag, may occasionally occur and can be mistaken for pulmonary ventilation.² However, our report shows that refilling of the bag during oesophageal ventilation was not significant in any of the patients and could not be repeated if no fresh gas flow was added during testing. In contrast, tracheal ventilation was followed by rapid refilling of the breathing bag during exhalation, and hence chest inflation could be repeated despite the continued interruption of the fresh gas supply. The test can be used as an additional method of assessing tube position after attempted tracheal intubation.

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An orotracheal tube with laryngeal hooks

Inadvertent bronchial intubation may be avoided more easily and cheaply than by recourse to laryngeal hooks (*Anaesthesia* 1988; **43**: 803). The length of the airway from the teeth to the midpoint of the trachea (between cords and carina) correlates well with the crown–heel length in patients of all ages from infancy to adulthood,^{1,2} and is more accurate than estimates based on age and weight, which may vary considerably between patients of the same height. The patient's height is seldom recorded outside paediatric anaesthetic practice, which is unfortunate since the length of an orotracheal tube may be calculated from the easily memorised equation:

$$\text{Length of tube (cm)} = \frac{\text{Height of patient (cm)}}{10} + 5 \text{ cm}$$

I usually add one or two centimetres for nasotracheal tubes.

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Propofol and the colour green

There are recent case reports of green urine associated with infusions of propofol,^{1,2} so we describe a case of green discoloration of hair which was possibly associated with a propofol anaesthetic.

A 42-year-old female presented for dilatation and curettage. Her general health was good and she took no medication other than vitamin C tablets. Some 4 years earlier she had suffered a severe attack of infective hepatitis, but this had eventually fully resolved.

Premedication was with atropine 0.6 mg and prochlorperazine 15 mg orally. Anaesthesia was achieved with propofol 140 mg after fentanyl 50 µg. Maintenance thereafter was with N₂O and 25% O₂. The procedure was uneventful and total time for anaesthesia was only 4 minutes. The patient was discharged home.

Approximately 48 hours later the patient began to notice her hair was turning green. She had done nothing out of the ordinary in the period after her anaesthetic and had not applied anything to her hair other than her usual shampoo. She became increasingly distressed at her appearance and finally went to her hairdresser to have most of her shoulder-length hair cut off. She then contacted the anaesthetic department.

On examination her head and pubic hair did indeed have an unnatural appearance, not of a lawn green, but a brassy colour with a slight green tint covering the entire length of the hair shafts. Her hair was silvery-blonde before operation; an appearance which had been achieved some 2 months earlier by 'highlights' to her normally light brown hair.

Initial investigations revealed normal urea and electrolytes and liver function tests. A small single sample of hair was then examined using X ray micro-analysis with a transmission electron microscopy machine. This technique did not detect copper (the usual cause of green hair) in the hair's cuticle. Further investigation using X ray fluorescence showed the concentration of copper in the patient's hair to be 28 (SE 6) ppm (normal range 11–32 ppm) com-

pared to 17 (SE 8) ppm in a normal control and 8 (SE 12) ppm in normal hair that had previously been 'highlighted'. Previous reports of copper-induced green hair have reported levels of 2750 ppm.³

The patient's hair is gradually returning to its former appearance after 3 months.

Previous cases of green hair have almost always resulted from contact with high levels of copper, such as in stagnant water from copper pipes in domestic plumbing.³ Copper does not appear to be the cause in this case and we have been unable to prove the role of any other agent. The only point of note in the history is the administration of propofol. This agent can cause green discoloration of urine through phenolic metabolites^{1,2} and it may be that a similar discoloration can occur with hair, possibly from metabolites excreted through sebaceous glands. It is also worth noting that this patient will probably have been at an increased risk of hair discoloration from whatever cause, because of the damage to hair that highlighting causes.³

We wish to acknowledge the technical assistance of Dr D.N. Slater, Consultant Histopathologist, Rotherham District General Hospital and Mr D.W. Thomas, Swansea *In Vivo* Analysis Research Group.

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Availability of past anaesthetic records

The inspection of a patient's previous anaesthetic records is an important and often informative part of any pre-operative assessment. All too often these records are missing, incomplete, or filed incorrectly. Examining the medical notes of 70 patients who presented for further anaesthesia it was apparent that a significant proportion had incomplete anaesthetic records.

All the past anaesthetic records could be accounted for in 55 of the patients' notes examined. However, of these, eight patients' records were inappropriately filed, generally loose in a pocket in the back of the notes along with the nursing Kardex, fluid and drug charts. Of more concern were the 15 patients whose past anaesthetic records were either absent or incomplete. Several of these patients had problems in which a previous anaesthetic record would have been helpful. These included a patient with a ventricular septal defect, another with a corrected coarctation of the aorta, a potentially difficult intubation and a patient

who gave a history of unspecified problems during the recovery from a previous anaesthetic.

It is clear we need to educate the ward staff concerned as to the significance and importance of our records. Operation notes were invariably filed correctly. An anaesthetic chart with integrated sections for consent, operation note and anaesthetic record did not prevent some of the charts from going missing. Possibly a dedicated anaesthetic section in the patient's medical notes, as suggested recently¹ may be one answer to this problem.

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Reference

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The Museum and Library at 9 Bedford Square

Many members have visited 9 Bedford Square since the Association took over the building nearly 3 years ago, either to attend one of the very successful seminars or symposia originated by the Immediate Past President, Professor M. Rosen, or for other reasons.

The house is open during working hours from Monday to Friday to members and visiting anaesthetists who may wish to sit for a while in its elegant drawing-room, talk to the staff or meet the Honorary Officers or other friends. They may also wish to pay a worthwhile visit to the Museum and the Library.

The British Oxygen Company Museum and the *British Journal of Anaesthesia* Library are developing steadily under the care of the ICI Archivist Dr A. Eccles. Many items have been added to the original Charles King collection of historic apparatus over the past 2 years and, although the space allocated to the Museum is generous, it is manifestly impossible to display the whole collection to-

gether at any one time. A policy of mounting changing exhibits on chosen topics has been adopted. The original exhibit on obstetric anaesthesia and analgesia has now been replaced by one commemorating the centenary of the birth of Sir Ivan Magill.

The Library does not attempt to compete with the major medical libraries but is specialising in historical and archival material based on the Bryn Thomas Collection of Historic Books. The major current English language anaesthetic journals and the British general medical journals are, however, taken and available for study.

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Uncomplicated accidental early tourniquet deflation during intravenous regional anaesthesia with prilocaine

Prilocaine is strongly recommended as the local anaesthetic of choice for intravenous regional anaesthesia (IVRA) on the grounds of safety when compared to other local anaesthetics.¹⁻³ A recent experience of ours lends support to this.

IVRA with prilocaine was selected as anaesthetic for a 75-kg, 60-year-old male with liver failure, due to undergo release of Dupuytren's contracture of the right hand. Sixty ml 0.5% prilocaine (4 mg/kg) were injected over 2 minutes, using a conventional technique employing an automatic double cuffed tourniquet, and with ECG and automatic blood pressure monitoring. One minute later the proximal cuff was deflated after it was falsely thought that the distal cuff had been inflated. There were no changes in conscious level, orientation, blood pressure or ECG in the ensuing minutes despite the immediate bolus of prilocaine into the circulation. The patient continued to converse normally. Questioned later, he had not noted any abnormal symptoms and was unaware of the event.

This case highlights once again the vulnerability of IVRA to faults in technique,^{1,4} but the most important

feature is the inadvertent but welcome reassurance of the margin of safety for prilocaine as agent of choice for IVRA. This is in direct contrast to the known toxicity of lignocaine⁵ and bupivacaine⁶⁻⁸ after both timed and premature cuff release.

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Facemask hazard

Certain types of neoprene antistatic facemasks have an encircling, strengthening malleable heavy-gauge metal wire. This can protrude through the fabric of the mask, possibly as a fault of design or manufacture, or because of damage while in use. We found a newish mask, from the inner surface of which an end of the metal wire was sticking out 0.5 cm (Fig. 1). The cause in this case is uncertain. There was the potential to injure a patient if it were used; we should always inspect the inside of facemasks as part of our pre-anaesthetic equipment check.

We have notified the manufacturer and the Department of Health of our discovery, and of the potential hazard.

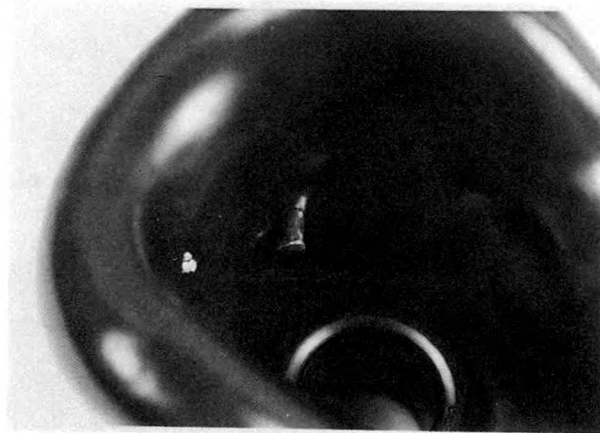


Fig. 1. The inside of the mask clearly showing the protruding wire.

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Occasional paediatric resuscitation: misuse of equipment

The inexperience of medical and nursing staff in resuscitation procedures has been studied and reported before.^{1,2} Recently I attended the resuscitation of a 2-year-old boy in an accident and emergency department which admits children occasionally. On my arrival, I found a junior member of the medical staff attempting to inflate the child's lungs with the apparatus assembled as shown (Fig. 1). There is considerable ingenuity involved in the connexion of the reservoir bag to the cuff of the BOC mask, but it is likely that W.W. Mapleson would not recommend the efficiency of the arrangement as a breathing system!

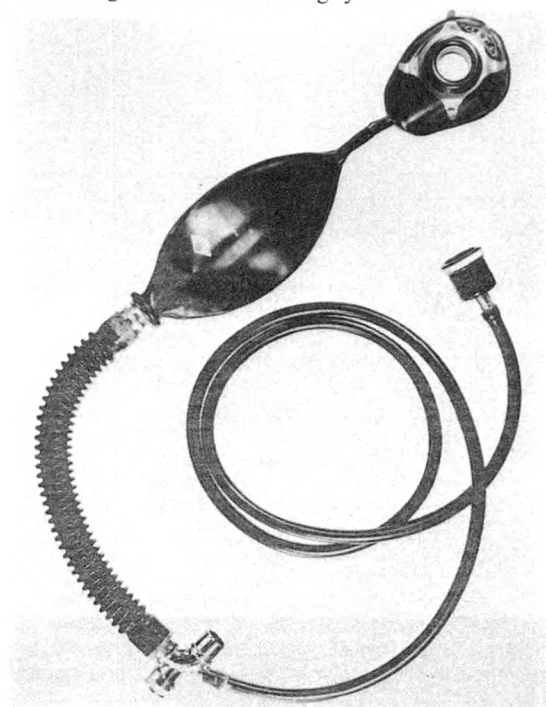


Fig. 1.

The paediatric resuscitation trolley now carries a photograph of the apparatus correctly assembled (Fig. 2); per-

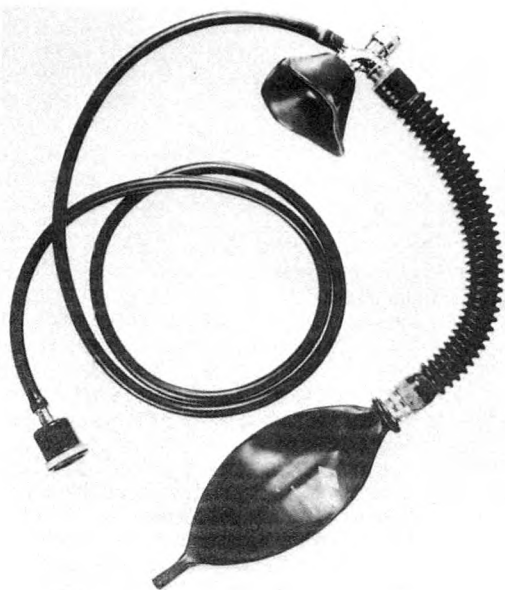


Fig. 2.

haps wherever equipment may occasionally be used by personnel unfamiliar with it, a photograph of its correct assembly could be displayed. This would, of course, supplement rather than replace efforts to improve training.

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An alternative to sedation during regional anaesthesia

Dr Allen (*Anaesthesia* 1988; 43: 426) describes the use of personal stereo cassette players for patients undergoing surgery under regional anaesthesia. The use of audiovisual methods to allay patients' anxiety is most worthwhile and effective, as his use of the stereo radio demonstrates.

We utilise a video player recorder in our unit (purchased for use during eye surgery) to show children's cartoons to small patients in the induction room. This is particularly effective even if the sound is rather loud to the adult ears. The video is switched off once induction is complete.

Adult patients under epidural, spinal or other regional anaesthesia have a choice of radio, taped music or television by request. Transurethral resection patients often listen to Handel's Water Music. One elderly woman about to undergo a total hip replacement regretted that she would miss her favourite midday show on television. She need not have

worried for she watched the whole programme with headphones so as not to disturb the surgeon, whilst her hip joint was replaced under spinal anaesthesia. Cricket fans watch test matches!

It is rare for our patients to request pharmacological anxiolysis or sedation. Our only regret is that our television, radio, cassette players which are also used for patients in intensive care, are black and white and now 10 years old. These days patients ask for colour television.

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The collator of this section is Dr L. Kaufman, MD, FFARCS, Anaesthetic Office, The Rayne Institute, University College, University Street, London WC1E 6JJ. Dr Kaufman is prepared to provide on request, and at a modest charge, a new additional service to our readers. References from January 1984 have been entered on data base. The data are held on Dbase II, cpm 86 and on Dbase III, MsDos and are available on disc, together with a program providing search facilities. Enquiries direct to Dr Kaufman at the above address please.

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Treatment and medication

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- Diabetes mellitus and anaesthesia. A survey of the peri-operative management of the patient with diabetes mellitus. DUNNET JM, HOLMAN RR *et al. Anaesthesia* 1988; **43**: 538.
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- Therapeutic applications of bromocriptine in endocrine and neurological diseases. HO KY, THORNER MO. *Drugs* 1988; **36**: 67.
- Improved metabolic control in insulin-dependent diabetes mellitus with insulin and tolazamide. KABADI UM, BIRKENHOLZ MR. *Archives of Internal Medicine* 1988; **148**: 1745.
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Treatment and medication

- A double-blind comparison between epidural morphine and epidural clonidine in patients with chronic noncancer pain. GLYNN C, DAWSON D, SANDERS R. *Pain* 1988; **34**: 123.
- Assessment of the analgesic efficacy of nefopam hydrochloride after upper abdominal surgery—a study using patient controlled analgesia. MCLINTOCK TTC, KENNY GNC *et al. British Journal of Surgery* 1988; **75**: 779.
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- Transcutaneous electrical nerve stimulation for pain relief following inguinal hernia repair. A controlled trial. SMEDLEY F, TAUBE M, WASTELL C. *European Surgical Research* 1988; **20**: 233.

Other

Physiology

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Treatment and medication

- Current management of malignant hypercalcaemia. STEVENSON JC. *Drugs* 1988; **36**: 229.

Obituaries

- Al-Azawi**, Sabah Abdul Salam, MB, ChB, FFARCSI, DA, formerly Consultant Anaesthetist, Lister Hospital, Stevenage. Qualified from University of Baghdad in 1967.
- Bannatyne**, Benjamin Neeve Peach, MB, ChB, FFARCS, DA, formerly General Practitioner in Ayr. Qualified from Glasgow University in 1935.
- Farman**, John Vernon, MB, BS, FFARCS, formerly Consultant Anaesthetist, Intensive Care Unit, Addenbrookes Hospital, Cambridge. Qualified from University College Hospital in 1954.
- Forrest**, Thomas, MB, ChB, FFARCS, formerly Consultant Anaesthetist, South Sefton HA. Qualified from Glasgow University in 1953.
- Gray**, Angus James, MRCS, LRCP, FFARCS, formerly Honorary Consultant Anaesthetist, Preston and District Group Hospitals. Qualified from Cambridge and St Barts in 1943.
- Johnston**, James, MC, TD, MB, ChB, FFARCS, DA, formerly Consultant Anaesthetist to Sheffield Health Authority. Qualified from Edinburgh University Medical School in 1940.
- Norlander**, Olof, MD, FFARCS, formerly Professor of Anaesthesia, University of Stockholm.
- O'Neill**, Maurice Brendan, MB, ChB, MD, FFARCS. Late Major RAMC. Qualified from University of Edinburgh in 1936.
- Parry**, John Wynne Lloyd, BSc, DM, FFARCS, TD, formerly Consultant Anaesthetist to Grampian Health Board. Qualified from University College Hospital in 1955.
- Shanks**, Jillian Ruth, MB, ChB, formerly Senior Registrar in Anaesthetics in the South East Thames region. Qualified from Otago Medical School in 1972.
- Willis**, Gertrude Aphra, MB, ChB, FFARCS. Qualified from Otago Medical School in 1935.
- Wilson**, Kathryn Margaret, MB, ChB, BAO, FFARCS, DA, formerly Consultant Anaesthetist to St James's Hospital, Balham, South London. Qualified from Trinity College, Dublin in 1956.

International congress calendar

1989

- 13-14 January.** London. *Winter Scientific Meeting, Association of Anaesthetists of Great Britain and Ireland.*
Information: The Honorary Secretary, Association of Anaesthetists of Great Britain and Ireland, 9 Bedford Square, London WC1A 3RA.
- 14-21 January.** Puerto Vallarta, Mexico. *7th Annual Symposium of the Mount Sinai Medical Center on Clinical Update in Anesthesiology.*
Information: Helen Phillips, Mount Sinai Medical Center, 1 Gustave L. Levy Place, Box 1010, New York, NY 10029, USA.
- 21-24 March.** Brussels. *Ninth International Symposium on Intensive Care and Emergency Medicine.*
Information: Dr J.-L. Vincent, Department of Intensive Care, Erasme University Hospital, Route de Lennik 808, B 1050, Brussels, Belgium.
- 28-31 March.** Nicosia, Cyprus. *8th Congress of the Greek Society of Anaesthesiologists.*
Information: 8th Congress of Anaesthesiology, Greek Society of Anaesthesiologists, 34 Dragoumi Street, 115 28 Athens, Greece.
- 13-15 April.** Yamaguchi City, Japan. *Annual Meeting of the Japan Society of Anaesthesiology.*
Information: Dr M. Fujita, 5F TY Building, 18-11 Hongo Chome 3, Bunkyo-Ku, Tokyo 113, Japan.
- 7-12 May.** Melbourne, Australia. *Faculty of Anaesthetists and the Royal Australasian College of Surgeons Annual General Meeting.*
Information: Administrative Officer, Faculty of Anaesthetists, RACS, Spring Street, Melbourne, Victoria 3000.
- 11-14 May.** Rotterdam. *Second European Congress of Paediatric Anaesthesia.*
Information: Mrs J.F. Aukes-Jager, Sophia Children's Hospital, Department of Paediatric Anaesthesia, Gordelweg 160, NL-3038 GE, Rotterdam.
- 17-19 May.** Lisbon. *VIII Annual Meeting of the European Society of Regional Anaesthesia.*
Information: Dr E. Lopes Soares, Rua Cidade de Cadiz 14, 1500 Lisboa.
- 26-27 May.** Cottbus. *III Bilaterales Anaesth. Schwesternsymposium DDR/CSSR.*
Information: Dr K.-H. Pickart, Karowerstr. 11, DDR-1115 Berlin-Buch, DDR.
- 9-13 June.** Ottawa. *Joint Meeting of the Canadian Anaesthetists' Society with the Association of Anaesthetists of Great Britain and Ireland.*
Information: The Honorary Secretary, Association of Anaesthetists of Great Britain and Ireland, 9 Bedford Square, London WC1B 3RA.
- 26-30 June.** Copenhagen. *20th Scandinavian Congress.*
Information: Professor S.H. Johansen, Herlev Hospital, DK 2730, Herlev, Denmark.
- 13-15 July.** London. *Refresher Course and Scientific Meeting of European Academy of Anaesthesiologists.*
Information: The Honorary Secretary, Association of Anaesthetists of Great Britain and Ireland, 9 Bedford Square, London WC1B 3RA.
- 12-16 August.** Christchurch. *Combined Meeting of New Zealand Society with the Australian Society of Anaesthetists.*
Information: Secretariat, ASA NZ Society of Anaesthetists, PO Box 600, Edgecliffe, NSW 2027, Australia.
- 23-25 August.** Oulu, Finland. *Scandinavian Meeting of the European Society of Regional Anaesthesia.*
Information: Secretariat, Scandinavian ESRA, Department of Anaesthesia, University of Oulu, SF 90220 Oulu, Finland.
- 1-4 September.** Tunisia. *3rd Pan Arab Congress of Anaesthesia and Intensive Care.*
Information: Dr Jamal Al-Shanableh, PO Box 15404, Marka-Amman, Jordan.
- 3-8 September.** Kyoto, Japan. *Fifth World Congress on Intensive and Critical Care Medicine.*
Information: The Fifth World Congress on Intensive and Critical Care Medicine, c/o Japan Convention Services Inc., Nippon Press Center Building, 2-2-1 Uchisaiwai-cho, Chiyoda-ku, Tokyo 100, Japan.
- 10-14 September.** Freiburg. *8th Congress of European Society of Pneumology.*
Information: Professor Dr med. H. Matthys, Arztlicher Direktor, Abteilung Pneumologie, Robert-Koch-Klinik, Universitat, D 7800 Freiburg, West Germany.
- 10-15 September.** Hong Kong. *6th World Congress on Emergency and Disaster Medicine.*
Information: Dr M. Moles, c/o Meeting Planners, 701 Tung Wai Comm Bldg, 109 Gloucester Road, Wanchai, Hong Kong.
- 12-16 September.** Austria. *International Conference on Anaesthesia, Intensive Care and Emergency Medicine.*
Information: Professor Dr J.M. Hackl, University Klinik fur An-

aesthesie und Allg. Intensivmedizin, Ahichstr. 35, A-6020, Innsbruck, Austria.

13-15 September. Swansea. *Linkman Conference and Annual Meeting of the Association of Anaesthetists of Great Britain and Ireland.*

Information: Honorary Secretary, Association of Anaesthetists of Great Britain and Ireland, 9 Bedford Square, London WC1B 3RA.

14-15 September. Osaka, Japan. *4th International Symposium of Endocrinology in Anaesthesia and Surgery.*

Information: Department of Anesthesiology, University of Hiroshima, School of Medicine, 5 Zaifu-cho, Hiroshima, Aomori-ken, 036 Japan.

17-19 September. Beijing. *1st International Symposium on Emergency Medicine.*

Information: Dr M. Moles, c/o Meeting Planners, 701 Tung Wai Comm Bldg, 109 Gloucester Road, Wanchai, Hong Kong.

18-22 September. London. *9th Congress of the Federation Internationale de Medecine Manuelle.*

Information: Conference Associates FIMM, 27A Medway Street, London, SW1P 2BD.

19-22 September. Tel Aviv. *15th International Congress of the Israel Society of Anesthesiologists.*

Information: Anesthesiologists 1989, PO Box 50006, Tel Aviv 61500, Israel.

27-30 September. Warsaw. *Joint Meeting between Association of Paediatric Anaesthetists of Great Britain and Ireland and Polish Society.*

Information: Dr J. Kacki, ul Kasprzaka 17A, 01-211 Warsaw, Poland.

4-7 October. Tunis. *Third Pan Arab Congress on Anaesthesia and Intensive Care.*

Information: Secretary, PO Box 15404, Marka, Amman, Jordan.

14-18 October. New Orleans. *American Society of Anesthesiologists Annual Meeting.*

Information: Executive Secretary, 515 Busse Highway, Park Ridge, IL 60068, USA.

18-20 October. Barcelona. *11th Congress of Chronical Roncopathy.*

Information: BRP, Edificio Layetana C-Pau Claris, 138, 08009, Barcelona, Spain.

26-28 October. Berlin. *3rd International Steglitz Symposium on Clinical aspects of O₂ transport and tissue oxygenation.*

Information: M. Specht, Klinik fur Anaesthesiologie und operative Intensivmedizin, Klinikum Steglitz FU-Berlin, Hindenburgdamm 30, D-1000 Berlin 45.

18-22 October. Tokyo and Kyoto. *6th World Congress for Bronchology.*

Information: Dr M. Niitsuma, Secretary General, 6th World Congress for Bronchology, Department of Surgery, Tokyo Medical College, 6-7-1 Nishishinjuku, Shinjuku-ku, Tokyo 160, Japan.

11-17 November. River Rhine. *International Symposium to commemorate '60 years of surfactant research'.*

Information: Professor B. Lachmann, Department of Anesthesiology, Erasmus University, PO Box 1738, 3000 DR Rotterdam, The Netherlands.

28 November-1 December. Manila. *6th ASEAN Congress of Anaesthesiologists.*

Information: PO Box 4486, Manila, Philippines.

1990

24-26 February. New Orleans. *Mardi Gras Anaesthetic Course.*

Information: Alan Grogono, Tulane University Medical Center, 1430 Tulane Avenue, New Orleans, Louisiana 70112, USA.

10-14 March. Honolulu. *64th Congress of the International Anaesthesia Research Society.*

Information: Emerson A. Moffitt, IARS, 3645 Warrensville Center Road, Cleveland, Ohio 44122, USA.

13-19 May. Wellington, New Zealand. *Faculty of Anaesthetics and the Royal Australasian College of Surgeons Annual General Meeting.*

Information: Administrative Officer, Faculty of Anaesthetists, RACS, Spring Street, Melbourne, Victoria 3000.

15-19 June. Vancouver. *47th Annual Meeting of the Canadian Anaesthetists' Society.*

Information: Ms Ann Andrews, CAS 187, Gerrard St. E., Toronto, Ontario M5A 2E5, Canada.

9-15 September. Warsaw. *VIIIth European Congress of Anaesthesiologie.*

Information: The Organising Committee, VIIIth European Congress of Anaesthesiology, c/o The Polish Society of Anaesthesiology and Intensive Therapy, ul. Kasprzaka 17a, 01-211 Warsaw, Poland.

23-28 September. Seoul. *8th Asian/Australasian Congress of Anaesthesia.*

Information: Department of Anesthesiology, Seoul National University Hospital, 28 Yungun-Dong, Chongro-Ku, Seoul 110.

26-28 September. Manchester. *Linkman Conference and Annual Scientific Meeting and Exhibition.*

Information: The Honorary Secretary, Association of Anaesthetists of Great Britain and Ireland, 9 Bedford Square, London WC1B 3RA.

19-23 October. Las Vegas. *American Society of Anesthesiologists Annual Meeting.*

Information: Executive Secretary, ASA, 515 Busse Highway, Park Ridge, IL 60068, USA.

5-10 November. Sao Paulo. *36th Brazilian Congress of Anesthesiology.*

Information: Dr R. Mathias, Rua Caiubi 666, Sao Paulo, Brasil 05010.

5-9 December. San Juan. *15th Caribbean Symposium in Anaesthesia and Related Fields.*

Information: Miguel Colon-Morales, PO Box 4547, San Juan, Puerto Rico 00936.

1991

8-12 March. San Antonio. *65th Congress of the International Anaesthesia Research Society.*

Information: Emerson A. Moffitt, IARS, 3645 Warrensville Center Road, Cleveland, Ohio 44122, USA.

9-12 May. Washington DC. *6th International Dental Congress on Modern Pain Control.*

Information: American Dental Society of Anaesthesiology, Inc., 211 E. Chicago Avenue, Suite 948, Chicago, IL 60611.

21-25 June. Quebec City. *48th Annual Meeting of Canadian Anaesthetists' Society.*

Information: Ms Ann Andrews, CAS, 187 Gerrard St. E., Toronto, Ontario M5A 2E5, Canada.

26-30 October. San Francisco. *American Society of Anesthesiologists Annual Meeting.*

Information: Executive Secretary, ASA, 515 Busse Highway, Park Ridge, IL 60068, USA.

1992

29 March-2 April. Atlanta, Georgia. *The Third International Symposium on the History of Anaesthesia.*

Information: R.K. Calverley, Medical Center, University of California, 225 Dickinson Street, San Diego, California CA 92103, 1990, USA.

14-19 June. The Hague. *10th World Congress of Anaesthesiology.*

Information: Dr Harm Lip, Nilantweg 99, 8041 AR Zwolle, The Netherlands.

17-21 October. New Orleans. *American Society of Anesthesiologists Annual Meeting.*

Information: Executive Secretary, ASA, 515 Busse Highway, Park Ridge, IL 60068, USA.

1993

15-17 September. Edinburgh. *Joint Meeting with the Canadian Society of Anaesthetists.*

Information: The Honorary Secretary, Association of Anaesthetists of Great Britain and Ireland, 9 Bedford Square, London WC1B 3RA.

9-13 October. Washington DC. *American Society of Anesthesiologists Annual Meeting.*

Information: Executive Secretary, ASA, 515 Busse Highway, Park Ridge, IL 60068, USA.

Safety Information Bulletin

These are issued regularly by the Department of Health

Electrically powered humidifiers: fitting of temperature monitoring probe (SIB(88)44)

When there is little or no gas flowing through the equipment excessive heat can build up in the system. This may result in accidental disconnection as a result of damage or softening of the breathing system. Furthermore, if the gas flow is suddenly increased the high temperature in the water reservoir may result in humidified gas being delivered to the patient at an unacceptably high temperature.

Failure to decontaminate Health Care equipment before inspection, service or repair (SIB(88)45)

The self evident need to decontaminate apparatus is emphasised. This also applies to external surfaces of apparatus sent for servicing etc.

Transcutaneous oxygen monitors—SIB(88)62

A Radiometer transcutaneous oxygen monitor (model TCM1b) caused burns on a baby. Model TCM1a could do the same. Modification kits are available from the manufacturers. See also Hazard Notice HN(Hazard)(80)8 1980.

Pulse oximeters: potential dangers during use (SIB(88)46)

The following problems are reported. They do not appear to be specific to particular makes or models. They include: interference from other equipment such as surgical lighting, diathermy and infrared lamps or heaters; potential burns at the probe site; reproducibility and accuracy of measurement; and problems of clinical interpretation of readings.

It is recommended that local evaluation and educational programmes are undertaken. It is important that users are aware of the possibility of burns at the site of the probe when diathermy is in use. Many probes are not impervious to water or saline solutions and they then act as a return pathway for high frequency currents.

Fibrelight sources: risk of patient burns and fire (SIB(88)49)

Skin and surgical drapes can be burnt when the fibre guide of a light source is uncoupled from a rigid endoscope with the light source at maximum intensity.

Cape Waine Anaesthetic Machines—SIB(88)71

Cape Waine anaesthetic ventilators require 2 litres of air to be entrained during the expiratory phase through the outlet port of the ventilator. If an anaesthetic gas scavenging system is connected to the outlet with tubing of inadequate length a substantial subatmospheric pressure is generated by the ventilator. Negative pressure relief valves are available.

Courses in Anaesthesia

(Supplementary list. See also *Anaesthesia*, 1988; **43**: 917–20)

The information below is believed to be accurate but those intending to attend a course should check the details with the relevant organiser. Applications and further information cannot be provided by *Anaesthesia*.

FCAnaes Part I

BRISTOL University Department of Anaesthesia, Bristol Royal Infirmary, Bristol BS2 8HW	23–30 January	£150	The University Secretary, Sir Humphry Davy Department of Anaesthesia, Bristol Royal Infirmary, Bristol BS2 8HW
OXFORD Nuffield Department of Anaesthetics, Radcliffe Infirmary, Oxford OX2 6HE	4–6 May	FEE ON APPLICATION	Regional Post-Graduate Office, John Radcliffe Hospital, Headington, Oxford OX3 9DU Tel. 0865 817425
LIVERPOOL University Department of Anaesthesia, Royal Liverpool Hospital, Liverpool L69 3BX	Lent term Half-day release (Wednesday mornings)	£200	The Postgraduate Secretary, University Department of Anaesthesia, Prescot Street, PO Box 147, Liverpool L69 3BX
LONDON Anaesthetic Office, The Rayne Institute, Room 107, University Street, London WC1E 6JJ	Combined part 1 and 2. Thursday day release 9 March–13 July	£250	Ms A. Greenwood, Anaesthetic Office, Room 107, The Rayne Institute, University Street, London WC1E 6JJ

FCAnaes Part II

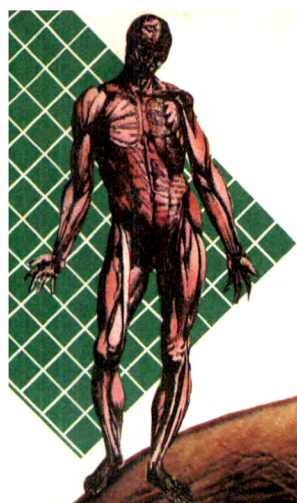
OXFORD Green College, Oxford OX2 6HG	5–18 March	FEE ON APPLICATION	Regional Postgraduate Office, John Radcliffe Hospital, Headington, Oxford OX3 9DU
LIVERPOOL University Department of Anaesthesia, Royal Liverpool Hospital, Liverpool L69 3BX	3–8 April One week whole-time revision course	£165	The Postgraduate Secretary, University Department of Anaesthesia, PO Box 147, Liverpool L69 3BX

FCAnaes Part III

LIVERPOOL University Department of Anaesthesia, Royal Liverpool Hospital, Liverpool L69 3BX	17–22 April One week whole-time revision course	£165	The Postgraduate Secretary, University Department of Anaesthesia, PO Box 147, Liverpool L69 3BX
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OTHER COURSES

OXFORD			
Anaesthesia for developing countries and difficult locations 5-day residential course	2-7 April	FEE ON APPLICATION	Nuffield Department of Anaesthetics, (Department ADC), Radcliffe Infirmary, Oxford OX2 6HE <i>Tel.</i> 0865 816246
Anaesthesia and intercurrent disease 3-day residential course	12-14 April	FEE ON APPLICATION	As above
Current trends in pain relief 5-day residential course	September	FEE ON APPLICATION	Oxford Regional Pain Relief Unit, Abingdon Hospital, Marcham Road, Abingdon, Oxon OX14 1AG <i>Tel.</i> 0235 22717 <i>Ext.</i> 250



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Prescribing Information: Norcuron vials of 10mg vecuronium bromide with 5ml ampoule water for injection. **Uses:** Non-depolarising neuromuscular blocking agent of short to medium duration. **Dosage:** Intravenous Initial 80-100 micrograms/kg. Incremental 30-50 micrograms/kg. Infusion 50-80 micrograms/kg/hr.

Contraindications: None known. Since there is no experience with the use of Norcuron in pregnant women, it cannot be recommended during pregnancy. Clinical studies show that Norcuron can be used in childbirth by Caesarian section without effect on the newly born child. **Precautions and warnings:** In renal insufficiency a slight prolongation of neuromuscular block can be expected. Use very small doses, and extreme caution in myasthenia gravis or myasthenic syndrome unless prolonged post-operative respiratory assistance is intended. Dose carefully in myopathy, severe obesity,

electrolyte disturbances, altered pH and after poliomyelitis or dehydration. Neuromuscular blockade can be reversed with adequate doses of neostigmine together with atropine. **Interaction:** It is dangerous to give depolarising drugs (e.g. suxamethonium chloride) following a non-depolarising drug (e.g. Norcuron). Alkylating drugs (nitrogen mustards) may be a hazard in anaesthesia involving muscle relaxants. Anaesthetics, other drugs and the condition of the patient, may affect the magnitude and/or duration of action of Norcuron—see Data Sheet. **Side-effects:** Rare reports of anaphylactoid type reactions when used in combination with other drugs. **Overdosage:** Use standard reversal agents, e.g. neostigmine or pyridostigmine. **Packs:** 20 vials 10mg Norcuron, 20 ampoules 5ml water for injection. PL: 3524/0013.

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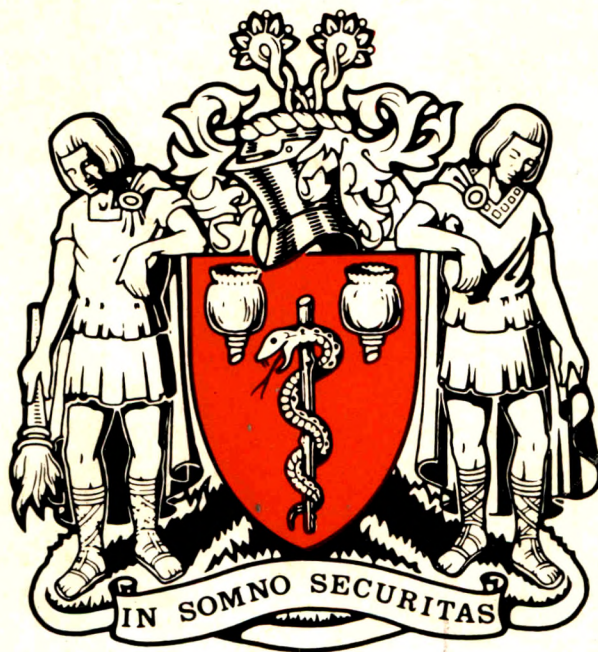
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Editorial

Is halothane obsolete? Two standards of judgement

Answers to the question about the continued use of halothane as an anaesthetic prove to be remarkably far removed from any scientific basis and become almost irrational. The, apparently sensible, argument is advanced that a ban on halothane will, *a priori*, protect anaesthetists from legal consequences; no halothane, no liver damage.

Discussion about halothane intensified after a symposium in Bristol,¹ several editorials,²⁻⁵ and a recommendation by the Committee on Safety of Medicines in the United Kingdom⁶ in 1986. But even after 'another step on a long path'⁷ we are still far from an answer to the question, about the relative safety for patients of halothane, enflurane and isoflurane.

Halothane is not a classic toxic liver agent: it possesses none of the three characteristics of a toxin: a dose-effect relationship, validity in different animal species, or a recognised mode of action. Stier and Rehder were the first to demonstrate that metabolism of halothane happened to about 20% of the amount administered.^{8,9} This opened the way to numerous investigations into the problem of metabolic paths involved in liver damage.

It is certain that halothane undergoes reductive and oxidative metabolism with the formation mainly of trifluoroacetic acid, chloride, bromide, and fluoride, and also of volatile radicals.¹⁰ The reversible liver damage with increase in transaminases¹¹⁻¹⁶ does not usually present clinically. Liver damage in animals, as admitted even by the most recent contributor,¹⁷ is precipitated by reductive metabolism (after repeated halothane anaesthesia in 20-25% of cases).

The extremely rare, fulminating, and under certain circumstances, fatal, liver failure seems to develop by way of oxidative metabolism¹⁸ and through an antigen-antibody reaction.^{10,19-23} The evidence for an immunological basis for the reaction was based on the almost exclusive appearance of liver failure after repeated halothane anaesthesia,¹ its earlier onset and more severe course,^{24,25} the reaction to provocative testing,^{26,27} the frequent demonstration of eosinophilia,²⁸ the correlation with allergies,¹ and the detection of auto-antibodies.²⁸ But it was the studies from King's College in London^{10,18,20-23} that provided the first evidence. This was confirmed by American researchers who found that the plasma of patients with liver failure after halothane contained antibodies against trifluoroacetic-acid-rabbit-plasma-albumin complex.^{19,29} It is however not possible to demonstrate antibodies in 20-30% of suspected cases.¹ It thus remains an open question whether a definitely pathogenetic significance should be attached to the antibodies demonstrated, or whether they are the consequences of another disease process.^{19,29,30}

The diagnosis of halothane-induced liver failure is possible only after exclusion of all other causes of post-operative disturbance of liver function.

Halothane remains a reliable anaesthetic which can be used in many clinical circumstances, as demonstrated on millions of occasions during the last 32 years.³¹ Sur-

prisingly, the incidence of unexplained hepatitis after halothane ranges from 1:2500³² to 1:36 000³³ and the mortality from 1:11 000³² to 1:210 000³² (for Tables see reference 34). The ways in which some statistical assertions are derived are given elsewhere.³⁴⁻³⁵ Methods to demonstrate hepatitis B have only existed since 1965,³⁶ and for hepatitis A since 1973³⁷ so that an unknown number of false-positive, unspecified cases of icterus may have been recorded in the past. The observation of the currently recognised contraindications should also lead to a reduced incidence. Halothane is particularly indicated for, even repeated, anaesthesia in children³⁸⁻⁴¹ in whom the morbidity of unspecified liver damage after halothane anaesthesia is only between 1:82 000³⁹ and 1:200 000.⁴¹

This remains undisputed despite two publications about halothane-induced liver damage in children in 1986,^{42,43} the absolute number, with less than 20 fatal episodes worldwide, is infinitesimally small.⁴⁰ It is impossible to specify a safe interval, but repeated anaesthesia in adults within 4 weeks is considered malpractice. The Committee on Safety of Medicines strongly advised in 1986 that the interval be extended to 3 months.⁶ Halothane is contraindicated, if undefined fever and jaundice have developed after previous halothane anaesthesia, or if antibodies against halothane-altered hepatocytes are demonstrated. Liver diseases such as chronic hepatitis, cirrhosis, and tumours do not constitute such a contraindication.³¹

The risks of halothane anaesthesia cannot be considered apart from the overall risks of anaesthesia. Anyone who desires to eliminate halothane must first consider the hazards of the alternative methods. Few publications^{44,45} on the incidence of death as a result exclusively of anaesthesia report a mortality as low as the most unfavourable studies on liver failure after halothane.

Possibly fatal (1:75 000) anaphylactic reactions occur only during or after intravenous anaesthesia.⁴⁶ It is, for example, calculated that there may be as many as 10 000 cases of severe morbidity after adverse reactions to intravenous agents in the United Kingdom each year; this is an incidence of about 1 in 333.⁴⁷

Similarly, if equally strict criteria were to be applied to spinal anaesthesia (epidural and subarachnoid) as to halothane, it is likely that no single indication for the former would remain. In Crawford's series,⁴⁸ for example, of 27 000 conduction anaesthetics adjacent to the cord, two healthy young mothers had to undergo laminectomy and there were nine potentially life-threatening incidents (1:3000). It is particularly obvious here that two different standards are employed for scientific discussion.

A questionnaire circulated to university departments of anaesthesia in the German Federal Republic in 1986³⁴ revealed that the incidence of so-called 'silent death'⁴⁹ (that is, death from inadequate supervision after neuroleptanaesthesia) was six times that of halothane-induced hepatotoxicity over a period of 10 years' observation.³⁴

Neither enflurane nor isoflurane are known to be superior to halothane in relation to the safety of anaesthesia. Differences about the speed of onset and recovery, the effect on circulation and respiration, the extent of muscle relaxation and alterations in intracranial pressure, though they exist, by no means indicate that halothane should be made obsolete; on the contrary, halothane shows up very well in these comparisons. The alleged advantages of enflurane and isoflurane (the lower rate of metabolism), must be viewed more sceptically today in the light of experience with halothane. If fatal liver failure after halothane is precipitated by an immune reaction with trifluoroacetic acid as the trigger agent, this possibility also exists for isoflurane, since trifluoroacetic acid is likewise formed in its metabolism^{50,51} and the quantity of a metabolite is not important in an immune reaction. The hepatotoxicity of enflurane cannot be excluded;^{52,53} hepatic dysfunction after isoflurane has been considered unlikely,⁵⁴ but further attention is necessary.⁵⁵

Enflurane reduces the cerebral convulsion threshold and may precipitate convulsive attacks even in those not so predisposed;⁵⁶⁻⁵⁸ this is described also with isoflurane.⁵⁹⁻⁶¹

Redistribution of the coronary circulation, first described by Reiz *et al.*⁶² is a most important feature in the evaluation of isoflurane. There are a few studies in man. Three different groups demonstrated disturbed autoregulation of myocardial perfusion⁶²⁻⁶⁶ in patients with coronary heart disease. Recent work⁶⁷⁻⁶⁹ has demonstrated that, similar to dipyridamol, isoflurane dilates intramyocardial arterioles, has negligible effect on epicardial conductance vessels⁶⁸ and can produce

myocardial ischaemia. Therefore, Becker concludes in an accompanying editorial, isoflurane is dangerous for some patients with coronary artery disease under some conditions.⁷⁰ Three out of six experts did not recommend the use of isoflurane in patients with coronary artery disease,⁷¹ at least not in concentrations greater than 0.75 vol%, while the other experts use it only as part of a narcotic/muscle relaxant technique. This issue has to be clarified before halothane is abandoned in favour of enflurane or isoflurane, even if isoflurane-induced coronary-steal should be dose-related.⁷²

It is not so important for most anaesthetists to know whether isoflurane can be employed in cardiac surgery as to know what the consequences may be, if isoflurane were to be used for routine clinical practice everywhere. Many patients with manifest heart disease or 'silent' myocardial ischaemia undergo many types of surgery and the anaesthetist needs to be sure that isoflurane will not cause myocardial ischaemia whose consequence will only become evident in the postoperative phase. Experience with isoflurane is still minute compared with that gathered over more than 30 years with halothane.

Anaesthetists strive to reduce anaesthetic risks and mortality, and it is important always to remain aware of the large numbers of patients at risk. We should also remember the risks we invent ourselves when we make measurements with double standards.

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Editorial notices

Anaesthesia News

Copy for *Anaesthesia News* should be sent to the Editor as and when it becomes available. It is hoped that publication will occur within 2 months of receipt.

Manuscripts must be submitted in accordance with the internationally recognised *Uniform requirements for manuscripts submitted to biochemical journals* (*British Medical Journal* 1979; **1**: 432-5). Details will be found in the Notice to Contributors to *Anaesthesia* at the end of this issue.

Postoperative absorption of controlled-release morphine sulphate

A study in patients given no parenteral opioids

J. K. L. LEW, K. A. MOBLEY, K. J. ACHOLA, M. HORNE AND G. SMITH

Summary

The absorption of morphine sulphate in a controlled-release formulation was studied in 12 patients who had undergone unilateral inguinal hernia repair under a light general anaesthetic and ilio-inguinal block. Serum morphine concentrations were measured serially and gastric emptying was assessed by measurement of paracetamol absorption. Three patients had delayed gastric emptying and impaired morphine absorption in the immediate postoperative period. Four hours later, there was a significant reduction in gastric emptying in eight patients who had normal paracetamol and morphine absorption in the immediate postoperative period.

Key words

Analgesics; oral morphine.

Pharmacokinetics; uptake.

Controlled-release oral morphine sulphate tablets (MST Continus, Napp Laboratories) have been used successfully for the relief of chronic pain¹ and for postoperative analgesia.^{2,3} Concern was expressed regarding their safety after several reports of respiratory depression after the use of MST.^{4,5} Delay in the absorption of MST in the immediate postoperative period^{6,7} prompted the manufacturers to recommend that MST should not be used during the first 24 hours after surgery. It was postulated that the slowing in gastric emptying which commonly occurs after anaesthesia and surgery might lead to the accumulation in the stomach of MST given at regular intervals. It is possible that subsequent 'dumping' from the stomach and absorption of the accumulated MST in the small intestine might result in dangerously high serum concentrations of morphine.

Gastric motility decreases in patients who have been given an opioid either for premedication⁸ or during the operation itself.^{9,10} In contrast, anaesthesia for minor surgery has little effect on gastric motility if no opioid is administered before or during operation.¹¹

The present study was designed to examine gastric emptying in the immediate postoperative period and 4 hours after a single dose of MST in a group of patients who had undergone minor surgery under a light general anaesthetic and a local anaesthetic block, and in whom no other opioid had been administered. Gastric emptying was assessed indirectly using the paracetamol absorption technique.¹²

Methods

Twelve patients (ASA grade 1) who underwent unilateral inguinal hernia repair were studied (mean age 49 years, range 32–63; mean weight 74 kg, range 60–92). The study was approved by the local ethics committee and informed written consent was obtained from each patient.

A standard anaesthetic technique was used for all patients. Oral diazepam 10–15 mg was administered as premedication. Anaesthesia was induced with thiopentone 3–4 mg/kg and maintained with nitrous oxide and halothane in oxygen. The patient was allowed to breathe spontaneously through a facemask and Bain system. A 16-gauge cannula was inserted into an antecubital fossa vein for sampling of venous blood. An ilio-inguinal block was administered on the appropriate side, using 15–20 ml of bupivacaine 0.5% plain.

The patient was returned to the recovery ward at the end of surgery. Baseline blood samples were taken after 30 minutes. The patient was given a 30-mg MST tablet and 750 mg of soluble paracetamol dissolved in 100 ml of water (time 0). Further blood samples were obtained at 15, 30, 45, 60, 90, and 120 minutes. The patient was then returned to the ward.

Further blood samples were taken 4 hours after the administration of morphine and paracetamol, and a second dose of 750 mg of soluble paracetamol in 100 ml water was

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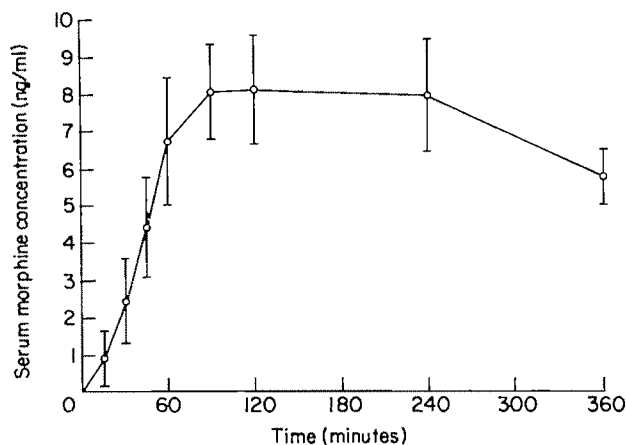


Fig. 1. Mean serum morphine concentrations after administration of MST 30 mg at time 0 in eight patients with normal paracetamol absorption. Bars represent SEM.

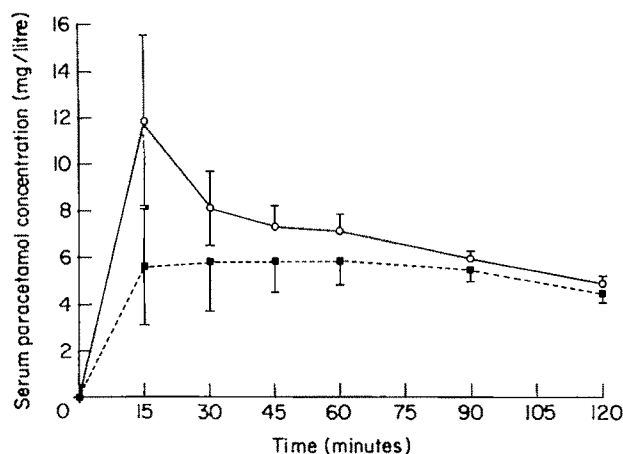


Fig. 2. Mean serum paracetamol concentrations after first dose of 750 mg of soluble paracetamol (○—○) and after a second dose 4 hours later (■—■) in eight patients with normal initial paracetamol absorption. Bars represent SEM.

given. Blood sampling was carried out at 15, 30, 45, 60, 90 and 120 minutes thereafter.

Throughout the period of study, the patient was not allowed to smoke and was permitted to drink only small quantities of clear fluids.

Blood samples were allowed to clot, and centrifuged at 6000 revolutions/minute for 15 minutes. The supernatant serum was extracted and stored at -70°C for analysis at a later date. Morphine concentrations were measured by high pressure liquid chromatography (HPLC) with electrochemical detection.¹³ Paracetamol concentrations were measured also by HPLC.¹⁴

Data were analysed statistically by paired Student's *t*-test, analysis of variance and Wilcoxon's rank sum test as appropriate.

Results

One patient was withdrawn from the study because of loss of blood samples. Of the remaining 11 patients, three exhibited marked initial delay in gastric emptying; serum paracetamol concentrations in these three patients increased gradually to reach a late plateau with no clearly defined peak. No morphine was detected in their serum during the first 60 minutes; subsequently, serum morphine concentration

increased to reach a peak (18.4, 6.0 and 12.8 ng/ml respectively) at 240 minutes. The second dose of paracetamol again demonstrated marked delay in gastric emptying.

Figure 1 shows the changes in mean serum morphine concentrations in the eight patients who exhibited normal gastric emptying after the first dose of paracetamol. There was a rapid increase towards a peak of 8.1 ng/ml at 90 minutes, and a slow decrease to 5.7 ng/ml at 360 minutes.

Changes in mean serum concentration of paracetamol after the two doses of paracetamol in the same eight patients are shown in Figure 2. There was a rapid increase in serum paracetamol concentration after the first dose of paracetamol to a peak of 11.9 mg/litre at 15 minutes; this was followed by a gradual decrease to a concentration of 4.8 mg/litre at 120 minutes.

The serum paracetamol concentrations after the second dose were calculated by subtracting the residual paracetamol concentration after the first dose from the measured concentration. Residual paracetamol concentrations were calculated using exponential extrapolation of the curve obtained after the first dose. The corrected mean serum paracetamol concentration after the second dose of paracetamol increased to 5.6 mg/litre within 15 minutes, and thereafter changed little within the subsequent 90 minutes.

The mean peak serum paracetamol concentrations after the first and second doses were 13.7 mg/litre and 8.5 mg/litre respectively; this difference was significant ($p < 0.02$). There was no significant difference in the time taken to reach the peak serum concentration (Table 1).

The areas under the serum paracetamol concentration-time curves (AUC) at 0–45 minutes and 0–90 minutes were significantly different for the two doses ($p < 0.02$ and $p < 0.04$ respectively; Table 2).

Table 1. Mean (SEM) peak plasma concentrations of paracetamol and time to achieve peak concentration in eight patients with normal gastric emptying in the immediate postoperative period.

	1st dose	2nd dose
Peak concentration (mg/litre)	13.7 (3.1)	8.5 (2.0) $p < 0.02$
Time to peak concentration (minutes)	31.9 (10.0)	56.3 (12.9) ns

Table 2. Mean (SEM) areas under the serum paracetamol concentration-time curves in eight patients with normal initial gastric emptying (AUC_{0-45} = area under curve from 0 to 45 minutes, AUC_{0-90} = area under curve from 0 to 90 minutes).

	1st dose	2nd dose
AUC_{0-45} (mg min/litre)	372.2 (82.7)	223.8 (78.1) $p < 0.02$
AUC_{0-90} (mg min/litre)	676.1 (100.4)	468.8 (112.7) $p < 0.04$

Discussion

In this study, only half the dose of paracetamol employed in previous studies^{11,12,15} was used to measure gastric emptying because two doses were administered within a relatively short interval.

There is relatively little information on the effect of anaesthetic drugs on gastric emptying although it is known that the administration of an opioid for premedication or peri-operative analgesia causes marked delay in gastric

emptying.¹⁶ A previous study¹¹ has shown that gastric emptying is normal after a short general anaesthetic during which opioid drugs are avoided. In our study, there was delayed gastric emptying 30 minutes after the end of anaesthesia in three out of 11 patients. As expected, these patients demonstrated impaired absorption of morphine.

The remaining patients exhibited a serum morphine profile comparable to that found previously in normal volunteers following ingestion of MST.¹⁷ These patients subsequently demonstrated a significant delay in gastric emptying 4 hours after ingestion of morphine as assessed by paracetamol absorption. In contrast, a previous study in volunteers¹⁵ suggested that MST 20 mg had little effect on gastric emptying 2 hours after ingestion.

Previous studies^{6,7} have shown that the rate of absorption of MST in the early postoperative period is reduced after anaesthesia that comprised intravenous opioid administration and nitrous oxide in oxygen. It was suggested that this was caused by opioid drugs given pre- or peri-operatively and other factors such as the effect of surgery itself on bowel motility. Our study has shown that even though these factors are not present, administration of MST itself may cause delay in gastric emptying so that the absorption of subsequent doses of MST is impaired. This confirms the view that there is the possibility of accumulation of large amounts of MST in the stomach if the drug is given at regular intervals in the postoperative period, and that the drug may be discharged subsequently into the small intestine. Absorption may result in toxic plasma concentrations of morphine. This risk may be increased if the initial delay in morphine absorption results in inadequate pain relief and further opioids are given parenterally.

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Cardiovascular responses to flumazenil-induced arousal after arterial surgery

G. C. FISHER AND P. HUTTON

Summary

Patients who underwent peripheral arterial surgery had anaesthesia maintained with an infusion of midazolam. They were allowed either to recover spontaneously or to have the effects of midazolam reversed by flumazenil at the end of surgery. This study demonstrated that the cardiovascular responses to arousal using flumazenil are no different from those seen when the patient is allowed to recover in the normal way. This result has obvious advantages for clinical practice but the dangers of resedation must not be forgotten.

Key words

*Antagonists, miscellaneous; benzodiazepines, flumazenil.
Hypnotics; benzodiazepines, midazolam.*

A considerable amount of literature on the clinical use of the benzodiazepine antagonist, flumazenil (Ro15-1788, Anexate) has accumulated, but the cardiovascular consequences of rapid reversal of sedation or anaesthesia in high risk groups have not been reported previously. It is known that after general anaesthesia the systolic and diastolic blood pressures and heart rate increase during arousal.¹ These changes occur at least in part because of increases in systemic vascular resistance and cardiac output secondary to sympathetic nervous activation.² One group of patients who show exaggerated responses to such changes are those with a rigid arteriopathy in whom the systolic arterial pressure is almost entirely dependent upon stroke volume.² It was therefore decided to study the cardiovascular effects of reversal of benzodiazepine-induced hypnosis with flumazenil in a group of patients with severe atherosclerosis who were presenting for arterial surgery on the lower limbs. The study described below had the approval of the Ethics Committee of the Central Birmingham Health Authority.

Methods

Informed consent for this study was obtained verbally from 20 patients who required lower limb vascular surgery. Patients on regular benzodiazepine therapy, and those with epilepsy were excluded. A cannula was inserted into the left radial artery, and blood pressure and ECG monitoring

started after premedication with 10 mg of temazepam. Anaesthesia was induced with intravenous midazolam, given at a rate of 5 mg/minute from a prototype Ohmeda CPI syringe pump. Either vecuronium or atracurium was used to facilitate tracheal intubation, and the lungs were ventilated to normocapnia with 60% nitrous oxide in oxygen. Anaesthesia was maintained with a midazolam infusion of 60 $\mu\text{g/kg/hour}$. Analgesia was provided by a loading dose of 50 $\mu\text{g/kg}$ of alfentanil followed by an infusion of 20–50 $\mu\text{g/kg/hour}$. The alfentanil infusion was adjusted intra-operatively in response to the effects of surgical stimulation. No further doses of relaxant or additional anaesthetic agents were given. The alfentanil infusion was reduced to 20 $\mu\text{g/kg/hour}$ at an estimated 30 minutes before the end of surgery. The midazolam and alfentanil infusions were maintained at their existing rates at the end of surgery and the patients were taken to the recovery area. Here their lungs were ventilated with oxygen-enriched air, and direct arterial pressure and ECG were monitored continuously. It was assumed that the nitrous oxide levels would be so low as to have negligible anaesthetic effects after about 15 minutes' ventilation. When the pulse rate and blood pressure were stable, the patient's level of consciousness was assessed using the scale given in Table 1 and his or her blood pressure and pulse rate were recorded. Patients were then allowed to recover consciousness by one of two methods. In Group 1 [11 patients, mean age 63.9 (SD 9.6) years; mean weight 64.1 (SD 9.0) kg], the midazolam infusion was

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stopped (defined as time zero), and flumazenil was given by slow bolus injection in doses of 100 µg at intervals of one minute until the patient's sedation score had reached Stage 2 (Table 1). Their tracheas were then extubated immediately and measurements of blood pressure, pulse rate, and sedation score were made one minute after extubation and at 15, 30, and 60 minutes.

In Group 2 [nine patients, mean age 66.4 (SD 9.3) years; mean weight 69.33 (SD 8.65) kg], the midazolam infusion was stopped and the patients were allowed to recover spontaneously. Their ECG, blood pressure and level of sedation were observed closely. The pulse and blood pressure before Stage 2 was achieved were recorded as baseline values. Extubation was accomplished and measurements of blood pressure, pulse rate, and sedation score were made one minute after extubation and at 15, 30, and 60 minutes immediately after Stage 2 had been attained.

In both Groups 1 and 2 the alfentanil infusion was maintained throughout the recovery period.

Results

The mean duration of the midazolam infusion was 189.3 minutes (SD 40.4 minutes) in Group 1 and 160.9 minutes (SD 66.8 minutes) in Group 2. The sedation score (Table 1) was six for all patients in both groups immediately before the midazolam was switched off. The doses of flumazenil required in Group 1 to reverse the midazolam were 200 µg in three patients, 300 µg in three patients, 400 µg in two patients, and 500 µg in three patients.

The mean time to arousal at the end of midazolam in Group 2 was 28.3 minutes (SD 18.7, range 9–60 minutes). The systolic and diastolic blood pressures and heart rates for the two groups before and after arousal are shown in Table 2. There are no statistically significant differences between any of these variables in the two groups at the same time periods when compared with an unpaired *t*-test.

The effect of arousal on the rate-pressure-product (RPP)

Table 1. Levels of sedation.

Score	Clinical state
1	Anxious, agitated or restless
2	Awake, cooperative. Oriented and responds to commands.
3	Asleep. Brisk response to light glabellar tap or loud auditory stimulus.
4	Asleep. Sluggish response to light glabellar tap or loud auditory stimulus.
5	No response to loud glabellar tap or loud auditory stimulus but responds to painful stimuli.
6	No response to painful stimuli.

Table 2. Average systolic (S) and diastolic (D) blood pressures in mmHg, and heart rate (R) in beats/minute. Values expressed as mean (SD).

	Before awakening			One minute after extubation			15 minutes after extubation			30 minutes after extubation			60 minutes after extubation		
	S	D	R	S	D	R	S	D	R	S	D	R	S	D	R
Flumazenil group (n = 11)	161.0 (40.8)	64.1 (19.1)	73.1 (11.6)	176.8 (43.8)	67.3 (14.5)	84.6 (15.1)	177.0 (42.4)	68.6 (21.6)	78.6 (14.3)	176.0 (49.0)	67.8 (21.4)	79.9 (12.5)	173.3 (44.0)	66.9 (23.8)	74.4 (8.9)
Control group (n = 9)	147.9 (23.2)	79.7 (14.2)	70.1 (6.0)	174.5 (34.3)	80.2 (15.1)	84.8 (10.3)	163.7 (31.0)	79.4 (11.9)	80.4 (7.2)	158.2 (28.7)	80.2 (13.6)	78.1 (5.5)	157.0 (27.5)	78.6 (13.1)	75.4 (6.8)

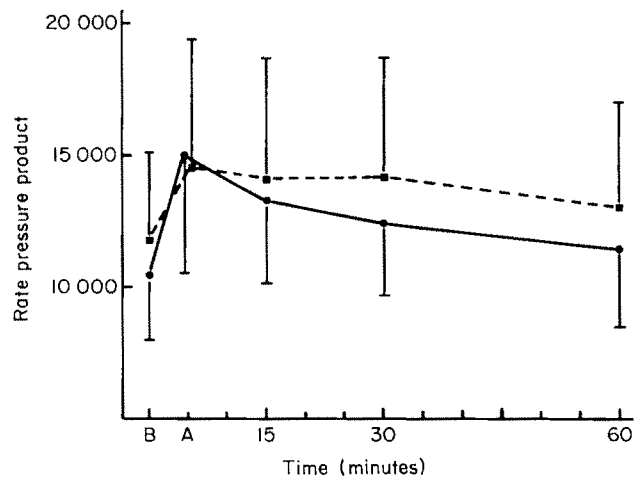


Fig. 1. Rate-pressure-product (mmHg beats/minute) for Group 1 (●) and Group 2 (■) at the various measurement times. Time B is before awakening when baseline measurements were taken. Time A is when awake one minute after extubation. The error bars show one standard deviation.

is shown in Figure 1. Using an unpaired *t*-test there are no statistically significant differences between the two groups at any of the measurement periods. All patients in both groups were asked when they awoke if they were in pain and replied 'no', and when asked if they were comfortable replied 'yes'. No patient in either group showed any ischaemic ECG changes during arousal or during the subsequent period of the study.

Discussion

This study measured the cardiovascular changes after arousal with and without flumazenil. The overall responses seen were obviously as a result of the combination of awakening and extubation. This sequence of events was chosen so as to mimic normal clinical practice as closely as possible and to ascertain whether or not it was safe to use flumazenil immediately after surgery had ended.

The alfentanil infusion dose used was determined from earlier experiments on patients similar to those in the study to establish a regimen which would allow a pain free recovery with adequate respiratory drive. As such, it is close to the level used by Andrews *et al.*³ and O'Connor *et al.*⁴ for postoperative analgesia after body surface surgery. It is important when interpreting the results of this study to remember that all the patients when aroused were pain free. Had this not been so, then it is possible that the sympathetic nervous responses might have been so great as to produce life threatening situations similar to those which have been associated with the injudicious administration of naloxone.⁵

The flumazenil was given by slow bolus injection at intervals of one minute as described. Our clinical impression was that it was necessary to wait for at least one minute to assess the pharmacodynamic effect of an injection before administering an additional dose. It became apparent from preliminary experiments that reversal of anaesthesia to sedation score 2 (Table 1) was usually achieved within a few minutes, that the patients could be extubated immediately, and that the changes in cardiovascular parameters were usually maximal at one minute. It was because of this sequence of events that one minute was chosen as our first measurement period, and in no case did the blood pressure or pulse rate exceed that recorded at this time. In Group 2, spontaneous awakening also occurred at sedation score 2 (Table 1) and this event was recorded as time zero. Extubation followed immediately. The blood pressure and pulse were recorded at the same time intervals (Table 2) for comparison between the two groups. The blood pressure and pulse rate never exceeded the values at one minute after extubation in all the patients in Group 2.

Patients undergoing vascular surgery almost always have overt or silent coronary artery disease and it is therefore important not to induce myocardial ischaemia during recovery from anaesthesia. For this reason, the rate-pressure product (RPP) was plotted in Figure 1. The RPP lacks specificity,⁶ but it is still a useful index of myocardial oxygen requirements and a guide to the risk of the onset of angina pectoris.⁷ It can be seen from Figure 1 that during arousal there is an increase in the RPP of both groups. What is important is that there is no greater increase in the RPP in the flumazenil group than there is in Group 2. This is despite the fact that the flumazenil group all awoke within 6 minutes of the end of the midazolam infusion whereas the patients in Group 2 did not awake spontaneously until a mean of 28.3 minutes (range 9 to 60 minutes) had elapsed. This ability to reverse anaesthesia safely when required has obvious advantages in clinical practice and may well rekindle interest in the use of midazolam as an anaesthetic agent. It is, however, essential to draw attention to the fact that the patients in the flumazenil group did show some temporary increase in drowsiness after approximately 30 minutes although on no occasion did they fall below stage 3 (Table 1). This resedation effect is perhaps

to be expected given that the elimination half-life of midazolam is 1.7–4.0 hours⁸ and that of flumazenil 0.7–1.3 hours.⁹ However, it draws attention to the dangers of using a minimum dose of flumazenil and early discharge of patients from the safety of a recovery area. All the patients in this study were observed for 2 hours after arousal and were fit to return to the ward at this time. More studies are required to quantify this problem of resedation and given the high therapeutic ratio of flumazenil⁹ it may be possible to use higher bolus doses or a longer acting preparation.

In conclusion, this study has demonstrated that using flumazenil in the presence of adequate analgesia, arousal from midazolam anaesthesia can be achieved safely immediately after the end of surgery. Furthermore the cardiovascular responses to arousal under these conditions are no different from those seen when the patient is allowed to recover normally. These results have obvious advantages for clinical practice but the dangers of resedation must not be forgotten.

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Instability of the tracheal tube in neonates

A postmortem study

R. ROOPCHAND, S. ROOPNARINESINGH AND S. RAMSEWAK

Summary

A postmortem study of the degree of displacement of the tracheal tube was performed on 13 neonates of varying birthweights. There was significant movement of the tube on flexion and extension of the neck, and on opening the infant's mouth. Our findings lend support to certain techniques of tracheal tube placement; the ultimate aim is to position it accurately.

Key words

Equipment; tubes, tracheal.
Anaesthesia; paediatric.

Efforts to attain the ideal position and stability of the tracheal tube during anaesthesia, intensive care and resuscitation of the newborn provoke feelings of anxiety, insecurity and fear among anaesthetists and neonatologists.^{1,2} Its migration downwards into one bronchus or upwards into the oropharynx is a potential hazard to the intubated neonate.³ The present study was undertaken in order to establish, by direct visualisation, the extent of displacement of tracheal tubes that resulted from movement of the head and neck of the infant.

Methods

Thirteen neonatal cadavers were dissected at the mortuary of the Mount Hope Maternity Hospital, after their weights were recorded, in order to display the tracheobronchial tree from the thyroid cartilage down to the main bronchi. Informed consent was obtained from the parents and our study was performed before routine postmortem examination. There were no anomalies of the head, neck and chest and no evidence of rigor mortis. The anterior ribcage, thymus, thyroid, heart, pericardium and large intrathoracic blood vessels were resected in each cadaver. The neck was secured in the neutral position, in which the head and neck are neither flexed, extended nor rotated.

The trachea was then intubated orally with a Portex noncuffed tracheal tube down to the level of the carina. The tube was measured from its tip to the point of fixation at the lip centrally, after its removal. This was achieved by the insertion of a straight wire probe from the tip of the tube to the point of fixation and its length was recorded.

The displacement of the tip of the tracheal tube was observed through a 'window', created anteriorly in the

Table 1. Length of orotracheal tube from lip to carina, tracheal length from tip of cricoid to carina, and birthweight.

Case	Birthweight (grams)	Tracheal length (cm)	Tube length (cm)
1	660	2.5	7.3
2	800	2.7	7.7
3	900	2.4	7.0
4	970	2.7	7.0
5	1640	3.7	9.0
6	1656	3.3	8.9
7	2240	2.8	9.0
8	2450	2.9	10.0
9	2800	3.5	8.5
10	2850	3.9	10.2
11	3330	3.3	10.0
12	3950	5.0	10.0
13	5200	4.5	13.5

midtrachea. The degree of displacement of the tube up or down the trachea, with each manipulation of the neck from the anatomical position, was recorded by the use of a pair of mathematical dividers. This instrument was also used to measure the length of the trachea, from the top of the cricoid cartilage to the carina. The effects of flexion, extension and lateral rotation of the neck were recorded, as well as those that occurred on opening the mouth with the tube fixed centrally at the mandible.

Results

Table 1 shows the various measurements obtained at each birthweight. Tracheal length ranged from 2.4 to 5.0 cm and the tracheal tube length ranged from 7.0 to 13.5 cm. Table 2 shows that full flexion of the neck from its anato-

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Table 2. Displacement of the oral tube produced on movement of head and neck.

Case	Size of tube (internal diameter)	Full flexion, caudad movement (cm)	Opening mouth, caudad movement (cm)	Full extension, cephalad movement (cm)	Lateral rotation
1	0.25	0.70	0.70	0.70	0.00
2	0.25	0.55	0.55	0.55	0.00
3	0.25	0.50	0.50	0.50	0.00
4	0.25	0.70	0.90	0.80	0.00
5	0.30	0.70	0.90	0.60	0.00
6	0.25	0.70	0.70	0.70	0.00
7	0.30	0.70	0.80	0.70	0.00
8	0.25	0.50	0.50	0.50	0.00
9	0.30	0.50	0.50	0.50	0.00
10	0.30	0.90	0.90	0.90	0.00
11	0.30	0.80	0.80	0.80	0.00
12	0.30	1.00	1.00	1.00	0.00
13	0.35	0.50	0.50	0.50	0.00

mical position produced a caudad movement of the tube tip, that ranged from 0.50 to 1.00 cm (mean 0.67 cm, SD 0.17). It was found that the tube moved into the right bronchus when the tip of the tube was at the level of the tracheal bifurcation. When the tube was fixed centrally at the lip to the mandible, opening the mouth with the neck in its anatomical position also caused a downward displacement of the tube into the right bronchus, that ranged from 0.50 to 1.00 cm, (mean 0.67 cm, SD 0.16). Opening the mouth with the neck in full flexion produced a summation effect, the caudad displacement of the tube ranged from 1.00 to 2.00 cm. Extension of the neck from its anatomical position moved the tube tip cephalad from the carina towards the glottis ranging from 0.50 to 1.00 cm (mean 0.72 cm, SD 0.19). The tube rotated about its longitudinal axis but there was no vertical displacement when the neck was rotated laterally.

Discussion

The observed movement of the tip of the tracheal tube caudally with flexion and cephalad with extension of the infant's neck is in agreement with previous studies in adults⁴ and in live infants.¹ Donn and Kuhns⁵ produced direct radiographic evidence of these changes in one neonate at autopsy and suggested the lever-fulcrum mechanism accounted for the displacement of the tracheal tube which occurs with change in head position.

Figure 1 illustrates the safety zone for positioning the tip of the tube; it has the midpoint of the trachea as its centre, and its length is proportional to the length of the trachea.

Measurements obtained in the present investigation reveal that if the tube tip is within the safety zone, the risk of inadvertent extubation with extension, or of displacement into the right main bronchus with flexion or opening the mouth, is minimised.

Equal and bilateral air entry on auscultation of the lungs, after intubating the trachea of a neonate is unsatisfactory on its own as a sign of correct placement of the tube.⁶ This situation exists when the tip of the tracheal tube sits just distal to the vocal cords or at the carina and, as shown in the study, this is not safe.

Tochen⁷ suggested that without the use of predictive charts the rule of 7–8–9 cm could be implemented for proper midtracheal positioning in infants that weighed 1, 2 and 3 kg, respectively. Furthermore, from their radiological study on 16 live neonates, Todres and colleagues⁸ recommended that routine radiographic interpretation of the tip of the tracheal tube should be correlated with the position of the infant's neck, but this is inappropriate for routine neonatal anaesthesia.

The present study lends support to the clinical technique suggested by Bloch⁹ which involves the intubation of one main bronchus (diagnosed by unilateral air entry) followed by slow withdrawal of the tube until air entry becomes bilateral. The tip of the tube at this point is at the level of the bifurcation of the trachea. The tube is finally withdrawn a further 1.5–2.0 cm thereby placing its tip at approximately the midpoint of the trachea. Our study further reveals that location of the tip of the tube at the bifurcation can also be confirmed by flexing the infant's neck. This should again result in unilateral air entry. It might be argued that the 1.5–2.0 cm withdrawal suggested by Bloch is longer than

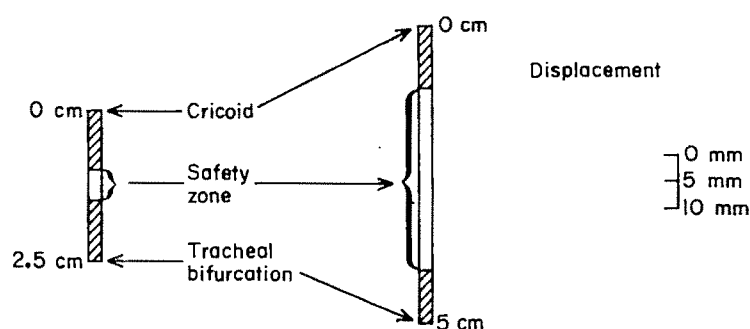


Fig. 1. Range of tracheal length, safety zone and observed displacement of tracheal tube tip, drawn to scale.

the 0.5–1.0 cm displacement recorded in our study, but this apparent discrepancy should be correlated with the fact that the trachea and consequently the safety zone is longer in the live infant than in the cadaver.⁷

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The oculo-emetic reflex

A rationalisation of postophthalmic anaesthesia vomiting

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Summary

Data related to the incidence of postoperative vomiting were collected during prospective studies on 607 ophthalmic surgical patients of all ages who underwent halothane anaesthesia with spontaneous ventilation. Analysis of data in respect of age, sex and surgical site variables, and time of onset of vomiting, identified a female sex-related vomiting incidence of about 13% and a squint-related vomiting incidence of about 41%; no relationship between age and vomiting was identified. The analyses showed that squint surgery predisposed particularly to emesis, and was associated with a high incidence of both early and delayed vomiting. It is suggested that the apparent absence of an age–vomiting relationship in ocular, and especially squint, surgery, and the high incidence of vomiting, particularly the early vomiting associated only with squint surgery, provide clinical evidence for the existence of an oculo-emetic reflex. Our observations show that intra- and postoperative surgical stimulation of this oculo-emetic reflex is reflected in the incidences of vomiting after ocular surgery.

Key words

Anaesthesia; ophthalmological.

Complications; vomiting.

Ocular surgery is reputed to be emetic in both children¹ and adults.^{2–4} A study of vomiting after ophthalmic surgery in this hospital⁵ revealed the emetic influence of surgical site. Intraocular operations were associated with a low emetic predisposition, and non-intraocular procedures, particularly squint correction surgery, with a higher emetic tendency. It was suggested that altered stresses in the squint-corrected eye were responsible, through a central reflex pathway, for the high incidence of vomiting after squint surgery.

The emetic sequelae of squint surgery performed under halothane anaesthesia with spontaneous ventilation are well described.^{6–9} However, many general factors, especially sex¹⁰ and age,¹¹ influence the incidence of postoperative vomiting. Data collected at this hospital during the above study, and further prospective studies on antiemetics (submitted for publication), intraocular pressure¹² and ventilation techniques (unpublished) in ophthalmic anaesthesia, were subjected to further retrospective analysis in order to determine whether all ophthalmic surgery is emetic,^{1–4} and to assess on clinical grounds whether a central reflex mechanism is involved in the high incidence of vomiting observed after squint surgery.⁵

Method

Four randomised controlled studies were conducted between 1983 and 1986 at the Riyadh Armed Forces Hospital

into the effects of premedication, peri-operative antiemetics and ventilation techniques in ophthalmic anaesthesia. These studies yielded a pool of postoperative morbidity data on 607 ASA grade 1 or 2 ophthalmic patients of all ages. There were three premedication groups. Group 1, which comprised 307 patients, derived from an antiemetic study⁵ and from an unpublished study of ventilation during ophthalmic surgery. They received intramuscular morphine (0.10–0.15 mg/kg) and atropine (6–8 µg/kg). Groups 2 and 3 comprised 150 patients each, and derived from two subsequent combination antiemetic studies (submitted for publication). They received either oral diazepam and metoclopramide (0.14 mg/kg of each) or oral diazepam with droperidol (0.07 mg/kg of each) respectively.

Peri-operative antiemetics were administered to the patients in these three groups as follows. Group 1 received either intravenous droperidol (0.035 mg/kg) with induction, intravenous metoclopramide (0.14 mg/kg), intramuscular prochlorperazine (0.18 mg/kg), or intravenous saline (1–2 ml) towards the end of the operative procedure. Group 2 received either droperidol (0.035 mg/kg), prochlorperazine (0.0875 mg/kg) or saline (1–2 ml) intravenously at induction of anaesthesia. Group 3 received either metoclopramide (0.14 mg/kg), prochlorperazine (0.0875 mg/kg) or saline (1–2 ml) intravenously at induction of anaesthesia.

Anaesthesia was induced in adults with a sleep dose of intravenous thiopentone; children received an inhalational induction. Tracheal intubation was performed after the

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administration of suxamethonium 1.5 mg/kg (pretreatment was given with alcuronium 0.03 mg/kg) and lignocaine laryngeal spray. Anaesthesia was maintained by spontaneous ventilation of nitrous oxide, oxygen and halothane, with the operating table inclined 10–15° head-up. All patients were given intravenous fluids until oral fluids were tolerated postoperatively. Pethidine, paracetamol and metoclopramide were prescribed for postoperative pain and vomiting.

Anaesthesia was administered or supervised by one of the authors (A.A.v.d.B.), who visited all patients on the day after surgery. A note was made of any incident of postoperative vomiting or retching as recorded by the anaesthetist or nursing staff, and verified by questioning of patient. Details of postoperative analgesic and antiemetic administration were recorded. Retches were recorded as vomits in view of their similar physiology.

Initial analyses compared patients (analysis of variance, Anova), vomiting incidences, analgesic requirement rates and the effects of analgesics on postoperative vomiting (Chi-squared tests) in each of the premedication and intra-operative antiemetic subgroups. Anova was performed on data after a logarithmic transformation to compare quantitative variables of three or more subgroups. Data pooled from the premedication and peri-operative antiemetic subgroups were then analysed to assess the effects of age, sex and surgical site on vomiting by two methods; an additive model using age, sex and type of operation with weighted analysis of the proportions in each cell, as described by Snedecor,¹³ and a multiple logistic regression¹⁴ using sex, age and type of operation as independent variables, and the presence or absence of vomiting as the dependent variable.

Finally, data regarding early postoperative vomiting (defined as that which occurred on the operating table at the end of anaesthesia or in the recovery ward) were extracted and analysed using Fisher's Exact Probability Test (FEPT).

Results

Comparability of groups (Table 1)

The premedication and antiemetic regimens yielded 10 subgroups of patients who were found to be similar in respect of age, weight, duration of anaesthesia (DOA), recovery ward time (RWT) and sex.

Effects of premedication and antiemetic agents on vomiting (Table 2)

No statistically significant difference in the incidence of vomiting occurred between saline (control) and the other antiemetic subgroups within premedication Groups 1, 2 and 3 ($p > 0.05$ for all comparisons). Analysed collectively, a significantly ($p < 0.05$) lower incidence of vomiting (18%) occurred in patients who received prochlorperazine. The overall incidences of vomiting were similar in the three premedication groups.

Effect of premedication on postoperative analgesic usage (Table 3)

All subgroups of patients premedicated with morphine required less postoperative analgesia than those premedicated with diazepam. This attained statistical significance in some subgroups, and overall.

Table 1. Comparison of patients in premedication study groups (1, 2 and 3) and in intra-operative antiemetic drug subgroups (saline control, droperidol, metoclopramide and prochlorperazine).

Premedication study group	Intra-operative antiemetic											
	Saline (control)			Droperidol			Metoclopramide			Prochlorperazine		
	M	F	Total	M	F	Total	M	F	Total	M	F	Total
1 Morphine and atropine												
Patient numbers	36	24	60	33	25	58	39	20	59	83	47	130
	Mean		Range	Mean		Range	Mean		Range	Mean		Range
Age, years	45		<1–74	49		<1–80	44		<1–83	46		<1–83
Weight, kg	49		4–76	55		5–94	47		4–98	52		4–98
DOA, minutes	81		25–185	69		20–165	69		30–190	69		20–140
RWT, minutes	41		20–75	38		10–95	43		5–180	39		15–95
2 Diazepam and metoclopramide												
	M	F	Total	M	F	Total				M	F	Total
Patient numbers	29	21	50	29	21	50				29	21	50
	Mean		Range	Mean		Range				Mean		Range
Age, years	52		<1–81	44		<1–84				53		2–85
Weight, kg	53		3–90	47		1–92				54		6–76
DOA, minutes	78		27–160	75		15–192				74		30–135
RWT, minutes	38		15–130	35		15–60				37		15–65
3 Diazepam and droperidol												
	M	F	Total				M	F	Total	M	F	Total
Patient numbers	30	20	50				29	21	50	28	22	50
	Mean		Range				Mean		Range	Mean		Range
Age, years	40		<1–90				51		<1–84	44		<1–88
Weight, kg	53		8–97				58		8–116	50		8–87
DOA, minutes	75		20–120				81		40–195	74		20–125

DOA, duration of anaesthesia; RWT, recovery ward time.

Table 2. Incidence of postoperative vomiting in premedication and intra-operative antiemetic study Groups 1, 2 and 3.

Premedication study group		Intra-operative antiemetic study groups					p
		Saline (control)	Droperidol	Metoclopramide	Prochlorperazine	Total	
1 Morphine and atropine	n	60	58	59	130	307	ns
	v	16 (27%)	16 (28%)	16 (27%)	26 (20%)	74 (24%)	
2 Diazepam and metoclopramide	n	50	50		50	150	ns
	v	10 (20%)	10 (20%)		7 (14%)	27 (18%)	
3 Diazepam and droperidol	n	50		50	50	150	ns
	v	18 (36%)		11 (22%)	8 (16%)	37 (25%)	
Total	n	160	108	109	230	607	< 0.05 saline vs. prochlorperazine
	v	44 (28%)	26 (24%)	27 (25%)	41 (18%)	138 (23%)	
p		ns	ns	ns	ns	ns	

n, patient number; v, number (percentage) who vomited; ns, not significant.

Table 3. Incidence of postoperative analgesic requirement as affected by premedication and intra-operative antiemetics.

Premedication study group		Saline (control)	Droperidol	Metoclopramide	Prochlorperazine	Total	p
1 Morphine and atropine	n	60	58	59	130	307	ns
	a	9 (15%)	8 (14%)	10 (17%)	35 (27%)	62 (20%)	
2 Diazepam and metoclopramide	n	50	50		50	150	ns
	a	23 (46%)	14 (28%)		19 (38%)	56 (37%)	
3 Diazepam and droperidol	n	50		50	50	150	ns
	a	21 (42%)		26 (52%)	20 (40%)	67 (45%)	
Total	n	160	108	109	230	607	
	a	53 (34%)	22 (21%)	36 (35%)	74 (35%)	185 (34%)	
p		< 0.01	ns	< 0.001	ns	< 0.001	

n, patient numbers; a, number (percentage) of patients who required postoperative analgesia; ns, not significant.

Table 4. Incidence of postoperative vomiting related to premedication and postoperative analgesic requirements.

Premedication study group		Patients who required postoperative analgesics		p	Patients who did not require postoperative analgesics	
		n	v		n	v
1 Morphine and atropine	n	55		< 0.05	252	
	v	19 (35%)			55 (22%)	
2 Diazepam and metoclopramide	n	56		ns	94	
	v	8 (14%)			19 (20%)	
3 Diazepam and droperidol	n	67		ns	83	
	v	18 (27%)			19 (23%)	
Total	n	178		ns	429	
	v	45 (25%)			93 (22%)	

n, number of patients; v, number (percentage) of patients who vomited; ns, not significant.

Effect of premedication and postoperative analgesic on postoperative vomiting (Table 4)

A significantly ($p < 0.05$) higher incidence of vomiting occurred in patients premedicated with morphine who received postoperative opioid analgesia compared with patients premedicated with diazepam. However, the mean incidences of vomiting (25% and 22%) were similar.

Effects of age, sex and surgical site on vomiting

There were no major differences in the incidences of vomiting among the subgroups, and consequently the data were pooled to provide the larger sample size necessary to assess the effects of age, sex and surgical site. Three surgical sites were considered: ocular (with intraocular, nonsquint ocular and squint subgroups); orbital; and combined sites. There

were significant differences in age and weight distributions among these groups and subgroups; patients who underwent intraocular surgery, or procedures at combined sites, were older, and those who had squint surgery were younger. Mean DOA and RWT were similar. Those with combined site surgery were omitted from the subsequent analysis due to the small number of patients (Table 5). Numbers in some subgroups are small, but no significant differential effects on emesis were produced by either the premedication or antiemetic changes within the surgical site groups ($p > 0.05$ all comparisons: Table 6).

Patient data within the operative site groups were then categorised by sex and three age spans: < 1 to 12 years; 13 to 48 years; and > 49 years, to assess sex, age and squint-specific emesis (Table 7). This analysis showed a significantly greater incidence of vomiting, regardless of age and sex, only after squint surgery ($p < 0.001$). Sex did not

Table 5. Comparison of patients grouped by anatomical site of surgery.

	Ocular												p
	Intraocular		Nonsquint		Squint		Orbital		Combined		Total		
Sex	M	F	M	F	M	F	M	F	M	F	M	F	
Patient numbers	242	156	39	35	50	20	25	28	7	5	363	244	ns
Total numbers	398		74		70		53		12		607		
	Mean	Range	Mean	Range	Mean	Range	Mean	Range	Mean	Range	Mean	Range	
Age, years	57	<1-90	30	<1-75	12	1-62	30	<1-79	61	18-81	46	<1-90	<0.01
Weight, kg	58	3-116	44	4-97	30	8-88	43	8-81	57	39-77	53	3-116	<0.01
DOA,* minutes	75	20-190	66	20-185	70	35-130	77	15-195	86	75-115	74	15-195	ns
RWT,** minutes	39	13-180	35	15-85	37	5-95	38	2-75	30	10-50	38	5-180	ns

* DOA, duration of anaesthesia.

** RWT, recovery ward time.

Table 6. Incidence of vomiting related to anatomical site of surgery and different premedications and intraoperative antiemetics.

Premedication study group	Peri-operative antiemetic		Site of surgery					Total
			Ocular			Orbital	Combined site	
			Intraocular	Nonsquint	Squint			
1 Morphine and atropine	Saline	n	35	11	8	5	1	60
		v	5 (14%)	2 (18%)	5 (63%)	4 (80%)	0 (0%)	16 (27%)
	Droperidol	n	39	7	5	4	3	58
		v	9 (23%)	2 (29%)	2 (40%)	1 (25%)	2 (67%)	16 (28%)
	Metoclopramide	n	37	3	13	5	1	59
		v	6 (16%)	0 (0%)	8 (62%)	2 (40%)	0 (0%)	16 (27%)
	Prochlorperazine	n	91	11	16	11	1	130
		v	16 (18%)	0 (0%)	9 (56%)	1 (9%)	0 (0%)	26 (19%)
Total	n	202	32	42	25	6	307	
	v	36 (18%)	4 (13%)	24 (57%)	8 (32%)	2 (33%)	74 (24%)	
2 Diazepam and metoclopramide	Saline	n	35	6	3	4	2	50
		v	8 (23%)	0 (0%)	2 (67%)	0 (0%)	0 (0%)	10 (20%)
	Droperidol	n	32	8	3	6	1	50
		v	3 (9%)	4 (50%)	2 (67%)	1 (17%)	0 (0%)	10 (20%)
	Prochlorperazine	n	32	6	4	5	3	50
		v	4 (13%)	0 (0%)	2 (50%)	1 (20%)	0 (0%)	7 (14%)
	Total	n	99	20	10	15	6	150
		v	15 (15%)	4 (20%)	6 (60%)	2 (13%)	0 (0%)	27 (18%)
3 Diazepam and droperidol	Saline	n	31	6	9	4	0	50
		v	9 (29%)	2 (33%)	5 (56%)	2 (50%)	0 (0%)	18 (36%)
	Metoclopramide	n	32	8	4	6	0	50
		v	6 (19%)	2 (25%)	3 (75%)	0 (0%)	0 (0%)	11 (22%)
	Prochlorperazine	n	34	8	5	3	0	50
		v	5 (15%)	1 (13%)	2 (40%)	0 (0%)	0 (0%)	8 (16%)
	Total	n	97	22	18	13	0	150
		v	20 (21%)	5 (23%)	10 (57%)	2 (15%)	0 (0%)	37 (25%)

n, patient numbers; v, number (percentage) of patients who vomited.

appear to affect the incidence of vomiting in orbital surgery, but the incidence was higher by 11 to 14% in females who underwent ocular surgery ($p < 0.01$; Table 8). Age had no significant effect on vomiting in ocular subgroups, but there was a significantly higher incidence in patients under 12 years of age who underwent orbital surgery than in other orbital subgroups ($p < 0.02$; Table 9). The equal incidences of vomiting that occurred after intraocular and nonsquint ocular surgery rationalised their combination for comparison with the squints (Table 10). An additive model that used sex and type of operation with weighted analysis of the proportion in each cell¹³ demonstrated that the interaction effect was -2%, with a standard error of 7.3%, i.e. nonsignificant. The analysis was continued to assess the main effects of both female sex and squint surgery. This identified a female sex-related vomiting incidence of about 13% and a squint-related vomiting incidence of about

41%, both of which are highly significant ($p < 0.001$). No significant relationship was identifiable between age and vomiting.

The analysis was then performed using a logistic regression model¹⁴ to test the results of the simultaneous effects on vomiting of age, sex and type of operation. This model supported the previous analysis, and demonstrated a non-significant age effect ($p = 0.13$) but highly significant sex and squint effects ($p < 0.001$ for both effects). The relative risks associated with each factor, and their respective 95% confidence intervals, are shown in Table 11.

Incidence of early vomiting

Early postoperative vomiting occurred in nine (2.3%) patients after intraocular surgery, in seven (10%) after squint surgery, in one (1.8%) after an orbital procedure and

Table 7. Incidence of vomiting related to anatomical site of surgery, age and gender.

Anatomical site		<1 to 12 years				13 to 48 years				49 to 96 years				Totals		
Group	Subgroup	M	F	Total	M	F	Total	M	F	Total	M	F	Total	M	F	Total
Ocular (total)	n	60	44	104	63	34	97	208	133	341	331	211	542			
	v	18 (30%)	20 (45%)	38 (37%)	18 (29%)	12 (35%)	30 (31%)	25 (12%)	31 (23%)	56 (16%)	61 (18%)	63 (30%)	124 (23%)			
	n	12	14	26	34	20	54	196	122	318	242	156	398			
	v	1 (8%)	7 (50%)	8 (31%)	6 (18%)	5 (25%)	11 (20%)	23 (12%)	29 (24%)	52 (16%)	30 (12%)	41 (26%)	71 (18%)			
Intraocular	n	32	15	47	16	6	22	1	-	1	49	21	70			
	v	16 (50%)	10 (67%)	26 (55%)	10 (63%)	4 (67%)	14 (64%)	0 (0%)	-	0 (0%)	26 (53%)	14 (67%)	40 (57%)			
	n	16	15	31	13	8	21	11	11	22	40	34	74			
	v	1 (6%)	3 (20%)	4 (13%)	2 (15%)	3 (37%)	5 (24%)	2 (18%)	2 (18%)	4 (18%)	5 (13%)	8 (24%)	13 (18%)			
Nonsquint	n	8	10	18	11	8	19	6	10	16	25	28	53			
	v	4 (50%)	4 (40%)	8 (44%)	1 (9%)	1 (13%)	2 (11%)	1 (17%)	1 (10%)	2 (13%)	6 (24%)	6 (21%)	12 (23%)			
	n	-	-	-	1	1	2	6	4	10	7	5	12			
	v	-	-	-	1 (100%)	1 (100%)	2 (100%)	0 (0%)	0 (0%)	0 (0%)	1 (14%)	1 (20%)	2 (17%)			
Orbital	n	68	54	122	75	43	118	220	147	367	363	244	607			
	v	22 (32%)	24 (44%)	46 (38%)	20 (27%)	14 (33%)	34 (29%)	26 (12%)	32 (22%)	58 (16%)	68 (19%)	70 (29%)	138 (23%)			
Combined site	n	-	-	-	-	-	-	-	-	-	-	-	-			
	v	-	-	-	-	-	-	-	-	-	-	-	-			
Total	n	60	44	104	63	34	97	208	133	341	331	211	542			
	v	18 (30%)	20 (45%)	38 (37%)	18 (29%)	12 (35%)	30 (31%)	25 (12%)	31 (23%)	56 (16%)	61 (18%)	63 (30%)	124 (23%)			
	n	12	14	26	34	20	54	196	122	318	242	156	398			
	v	1 (8%)	7 (50%)	8 (31%)	6 (18%)	5 (25%)	11 (20%)	23 (12%)	29 (24%)	52 (16%)	30 (12%)	41 (26%)	71 (18%)			

n, patient numbers, v, number (percentage) of patients who vomited.

Table 8. Incidence of postoperative vomiting related to gender, anatomical site and type of operation.

Site and type of operation	Gender			p
	Male	Female	Difference	
Orbital	n 25	28		
	v 6 (24%)	6 (21%)	(3%)	ns
Ocular				
Intraocular	n 242	156		
	v 30 (12%)	41 (26%)	(14%)	<0.01
Non-intraocular				
Nonsquint	n 40	34		
	v 5 (13%)	8 (24%)	(11%)	<0.01
Squint	n 49	21		
	v 26 (53%)	14 (67%)	(14%)	<0.01

n, patient numbers; v, number (percentage) of patients who vomited; ns, not significant.

Table 9. Incidence of vomiting related to patient age, anatomical site and type of operation.

Vomiting	Age (years)			p
	<1–12	13–48	>49	
Orbital	n 18	19	16	
	v 8 (44%)	2 (11%)	2 (13%)	<0.02
Ocular				
Intraocular	n 26	54	318	
	v 8 (31%)	11 (20%)	52 (16%)	ns
Non-intraocular				
Nonsquint	n 31	21	22	
	v 4 (13%)	5 (24%)	4 (18%)	ns
Squint	n 47	22	1	
	v 26 (55%)	14 (64%)	0 (0%)	ns

n, patient numbers; v, number (percentage) of patients who vomited; ns, not significant.

in two (2.7%) after nonsquint ocular surgery. The higher rate associated with squint correction was significant ($p = 0.006$; FEPT, two tailed) when compared to the combination of the three other groups.

Discussion

Analysis of data gathered during our four successive studies on morbidity after ophthalmic anaesthesia made us sceptical of the belief that all ophthalmic procedures are associated with a high incidence of vomiting, and suggested the possibility of an oculo-emetic reflex. Patient data collected during these individual studies were surprisingly similar overall. Some differences were elicited by study group comparisons; the overall beneficial antiemetic effect of prochlorperazine; the lesser analgesic requirements of patients premedicated with morphine; and an apparent additive emetic effect of postoperative opioid given to patients premedicated with morphine. These findings were considered to have important clinical implications, but did not preclude pooling of all data in an attempt to analyse other factors that contributed to vomiting.

Review of the literature reveals that squint surgery is associated with incidences of vomiting that range from 56% to 85%.^{6–9} However, the reported incidences of up to 50% after adult ocular surgery^{2,3,5,15} are no higher than those associated with nonocular surgery, in which rates of up to 68% have been reported.^{10,11,16–20} Our finding in each premedication study group, and overall, of an incidence of vomiting between 18% and 23% for all nonsquint ophthal-

Table 10. Incidence of vomiting related to gender in patients who underwent ocular surgery.

Gender	Type of operation		
	Squint	Nonsquint	Difference
Female	n 21	190	
	v 14 (67%)	49 (26%)	41%
Male	n 49	282	
	v 26 (53%)	35 (12%)	41%
Difference	13.6%	13.4%	

Main effects: female sex effect, 13% (SEM 3%) $p < 0.001$, 95% CI (7%–19%); squint effect, 41% (SEM 2.8%) $p < 0.001$, 95% CI (35%–47%); interaction effect, –2% (SEM 7.3%) $p > 0.2$. n, patient numbers; v, number of patients (percentage) who vomited; CI, confidence interval.

Table 11. Multiple logistic regression. Relative risk estimate of effects of age, gender and site/type of surgery on risk of vomiting.

	Relative risk	95% Confidence interval	p
Age (years)			
<1–12	1.3	0.9–1.8	ns
13–48	1.1	0.7–1.5	ns
49–96	1		
Gender			
Female	1.6	1.2–2.3	<0.001
Male	1		
Site/type of surgery			
Squint	2.9	1.8–4.6	<0.001
Nonsquint ONIO*	1.1	0.5–1.6	ns
Orbital	0.9	0.4–1.5	ns
Intra-ocular	1		

* Nonsquint ocular non-intraocular.

mic surgery, and of 50% to 67% after squint surgery, appears to show that only surgery for squint correction is especially emetic.

We were not able to identify a relationship between age and vomiting in ocular surgery, but were able to identify a female sex-related vomiting incidence of about 13% and a squint surgery-related vomiting incidence of about 41%. Quantification of these factors suggests a ‘vomiting predictor model’ for ocular surgery, yet to be tested prospectively, which predicts a baseline vomiting incidence after nonsquint ocular surgery of 12% in males and of 25% (12 + 13%) in females, and of 53% (12 + 41%) in males and of 66% (12% + 13% + 41%) in females after squint surgery. The major value of this analysis, however, is the approximate quantification of the female predisposition and of the predisposition to vomiting associated with squint correction.

Squint correction surgery in most European and North American centres is performed mainly in young patients; however our patients are of all ages, from 1 to 62 years. This enabled us to demonstrate that age has no obvious effect on the incidence of vomiting after squint surgery. We observed a high incidence of early vomiting only after squint surgery; there were low incidences after nonsquint ocular and orbital surgery (10% compared with 1.8% and 2.7%). Early vomiting occurs when patients are still drowsy, with the operated eye bandaged, and thus a visual cortical emetic aetiology is improbable. Collectively, these

findings provide strong clinical evidence for a centrally-mediated reflex that arises from stresses and strains in the squint-corrected eye, as has been hypothesised by others.^{3,21,22} The existence of this reflex could explain, and in turn be quantified by, the high incidence of vomiting after squint surgery identified in this study. Such a reflex may account for the variable vomiting rates reported after ophthalmic surgery in which differentiation between squint and nonsquint surgery is not made. The data from the present analysis support our earlier contention that squint surgery alone is primarily responsible for ophthalmic anaesthesia's emetic reputation.⁵

Further evidence to support the existence of the reflex is provided by our observations in other ocular procedures. Traumatic operations, such as cyclocryotherapy and retinal detachment surgery, which involve severe intra-operative manipulation of the eye with marked residual eye discomfort, are associated with modest increases in the incidences of early and delayed vomiting (6%, 1 of 14 patients and 29%, 4 of 14 patients respectively). Nontraumatic intra-ocular procedures, such as cataract surgery, in which there is little intra-operative eye manipulation and minimal post-operative eye discomfort, have low incidences of vomiting (2.3%, 9 of 398 patients and 18%, 72 of 398 patients). Subtle stimuli that arise from maintained stresses in the musculature of the squint-corrected eye appear to stimulate this oculo-emetic reflex most profoundly, but any ocular stimulus would have the potential to do so. This may explain the emesis seen in ocular pathology such as acute glaucoma.

The oculocardiac reflex, described first by Aschner²³ and Dagnini²⁴ in 1908, is inhibited by atropine premedication.²⁵ Atropine also reduces emesis after squint surgery.⁶ This suggests similar neural pathways for both reflexes. However, the oculocardiac reflex produces intra-operative morbidity (arrhythmia) which is unperceived by the patient, whereas the oculo-emetic reflex induces morbidity (vomiting) postoperatively, and is more likely to be perceived by, and distressing to, the patient.

We conclude that this unique propensity of squint surgery to promote vomiting, the absence of a demonstrable age relationship in the incidence of vomiting after ocular surgery and the high early vomiting rates after squint surgery, confirm the existence of an oculo-emetic reflex. We suggest that suppression of the contribution of this reflex to vomiting by use of either pre-operative anticholinergics⁶ or of adequate doses of antiemetics²⁶ is advisable, both to reduce the morbidity of vomiting after squint surgery, and the hazard of vomiting after intraocular surgery.

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A new method of analgesia for relief of circumcision pain

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Summary

A prospective, randomised, double-blind study was designed to determine whether topical application of 2% lignocaine is effective in decreasing analgesic drug requirements during and after circumcision surgery. General anaesthesia with halothane and nitrous oxide 60–70% in oxygen was administered via a facemask and a Bain system. Administration of halothane was stopped after removal of the foreskin; lignocaine (2%) or placebo was applied topically as drops to the surface of the penis to two groups of patients. Halothane was restarted if the anaesthesia was ineffective. The intra-operative consumption of halothane was significantly less ($p < 0.05$) in the treated group as compared with the placebo group (0 and 17, SEM 3, % \times minute). The treated group required significantly less ($p < 0.002$) pethidine after operation (5 and 10 patients), and the pain-free period was significantly longer ($p < 0.01$) (41, SEM 6 and 6, SEM 2 minutes) as compared with the placebo group.

Key words

Anaesthetic techniques; regional, topical.

Pain; postoperative.

Good analgesia with minimal side effects is particularly important in paediatric surgery such as circumcision. The several techniques described for pain relief in children include systemic administration of narcotics,^{1–3} blockade of the dorsal nerve of the penis,^{4,5} caudal block^{6,7} and topical application of lignocaine ointment or jelly.⁸ However, all these studies considered solely analgesia after operation. The purpose of the present study was to investigate the intra-operative use of topical lignocaine on the undersurface of the foreskin of the penis, after the foreskin is removed.

Materials and methods

Twenty-four otherwise healthy children scheduled for elective circumcision were studied. Informed consent was obtained from all parents and the study was approved by the Copenhagen Committee on the Ethics of Science. Pre-medication was with diazepam (0.7 mg/kg) per rectum, given one hour before the procedure. The operation was done with a standard surgical technique by different surgical staff or residents.

The patients were randomly assigned to one of two groups: lignocaine 2% or placebo isotonic NaCl. Neither the investigator, surgeons, nurses nor patients (nor their parents) knew the allocation.

General anaesthesia consisted of halothane 1.5–3% and nitrous oxide 60–70% in oxygen administered with a face-

mask, through a Bain system with all patients breathing spontaneously. The halothane concentration was noted minute by minute before and after the removal of the foreskin. Heart rates were determined with an ECG rate meter.

When the foreskin was removed the investigator started to apply lignocaine or saline with a 10-ml injection syringe onto the undersurface of the residual foreskin to a maximum of 10 ml. The halothane administration was stopped and anaesthesia continued with nitrous oxide 60–70% in oxygen and a drop from the syringe now and then. If the patient's heart rate increased and (or) the patient began to move, the halothane administration was restarted so that the heart rate was maintained at the pre-operative value. The duration of the operation was recorded. The children received rectal pethidine 2 mg/kg in the recovery room if they started to complain or cry from pain. The time from the end of the operation to the start of pain was defined as the pain-free period. If they were discharged from the recovery room and then started to complain or cry from pain, the time and the type of analgesic was noted at the ward; pethidine 2 mg/kg (rectally) and (or) lignocaine jelly 2% was applied topically. Blood samples for determination of plasma levels of lignocaine were taken 5, 15, 30, 60, 80 and 90 minutes after the start of the lignocaine in four patients. Based on the characteristics of the data a Mann-Whitney test or Fisher's exact test was used to determine whether the two groups differed significantly. Statistical significance was assumed at $p < 0.05$.

Table 1. Details of patients and results. Values expressed as mean (SEM).

	Saline	Lignocaine
Number	11	13
Age, months	67 (14)	69 (10)
Weight, kg	23 (4)	23 (2)
Duration of surgery, minutes	34 (2)	32 (3)
Halothane consumption <i>before</i> application of lignocaine, % \times minutes	23 (2)	25 (1)
Halothane consumption during analgesia with lignocaine, % \times minutes	17 (3)	0*
Pain-free period, minutes	6 (2)	41 (6)*

* $p < 0.05$.**Table 2.** Results after operation. Values expressed as mean (SEM).

	Saline	Lignocaine
Number	11	13
Number of patients who received analgesics after operation, %	10 (91)	10 (77)
Number of patients who had pethidine.	10	5*
Number of patients who had lignocaine jelly	0	5*

* $p < 0.02$.

Results

The average age was 68 months (range 18–152 months). There was no significant difference between the groups in terms of age, weight, duration of operation, or the accumulated product of halothane concentration and duration of administration, before the start of the topical lignocaine ($p > 0.1$) (Table 1).

There was a significant difference between the control and the treatment group in the cumulative halothane concentration and duration of administration product, after the start of the topical analgesia ($p < 0.05$), and with regard to the length of the pain-free period ($p < 0.01$), (Table 1). There was also a significant difference between the two groups in the amount of analgesics given ($p < 0.002$), and the type of analgesic required to relieve pain after discharged from the recovery room ($p < 0.02$) (Table 2). Blood samples showed concentrations below $0.25 \mu\text{g/ml}$.

Discussion

Circumcision in infants is associated with severe intra-operative and postoperative pain which may cause restlessness, agitation and bleeding. All current techniques used to control postoperative pain after circumcision have complications and side effects. Parenterally administered narcotics cause respiratory depression and nausea or vomiting.³ Dorsal nerve block can, without proper precaution, cause a haematoma and possibly gangrene,¹⁰ from accidental puncture of the dorsal artery or vein of the penis during the attempt to infiltrate the dorsal nerves, which lie deep to Buck's fascia. Such serious complications may be avoided if a simple ring block of the penis is performed.⁹ Caudal blocks can cause respiratory depression, dural puncture and require special skills.¹¹ Topical lignocaine has been reported by Tree-Trakarn *et al.*⁸ to provide effective postoperative pain relief after circumcision performed under general anaesthesia. Compared to the present technique, topical an-

algesia with lignocaine ointment is as easy to perform as the lignocaine solution analgesia, so it can be used by parents to provide postoperative analgesia after discharge. Intra-operative, topical lignocaine cannot be used in the form of jelly or ointment, because it will make the penis slippery and interfere with surgery. The present technique using aqueous solution of lignocaine not only provides analgesia but the drops of lignocaine help to keep the field clean. The present method of analgesia cannot be used alone to provide operative analgesia, because lignocaine does not penetrate intact skin; it will only penetrate the undersurface of the foreskin, and the exposed nerve endings and skin edges which remain after surgery. Once the foreskin was removed and the lignocaine application begun, the analgesia was sufficient to allow halothane to be discontinued so that anaesthesia could be continued with 60–70% nitrous oxide and oxygen alone. The pain relief achieved by this method during the operative procedure, as assessed by heart rate and movement of the child, appeared to be equal to that of halothane. Later analgesic requirements in the recovery room, could usually be met by the use of topical lignocaine jelly. The absorption of lignocaine from the wound did not cause toxic levels to be reached in the plasma, that is not greater than $8.0 \mu\text{g/ml}$.^{12,13}

Interpretation of our data about the period after the operation should be cautious since it is obvious that the indications for pethidine or further lignocaine jelly were not stringently applied. Nevertheless the duration of the pain-free intervals in the two groups is very impressive.

Topical application of aqueous lignocaine by this means has several advantages. The technique is simple and requires no special skills. It not only reduces the need for other anaesthetic agents with their attendant disadvantages, but also provides for a smooth transition into the postoperative period.

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CASE REPORT

Anaphylaxis due to suxamethonium in a 7-year-old child: a 14-year follow-up with allergy testing

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Summary

In 1973 a 7-year-old girl had anaphylactic reactions after two general anaesthetics. In-vitro testing with the leucocyte challenge histamine release test showed a strong response to suxamethonium, and other tests indirectly suggested an allergic mechanism. The conclusion was that this was an allergy to suxamethonium. Further blood was sent for testing against a range of neuromuscular blockers, but the patient was 'lost' until she re-appeared 14 years later as an antenatal patient. In-vitro testing was repeated against suxamethonium and all the available neuromuscular blockers after delivery. The radio-allergosorbent test for allergen-specific IgE antibodies was performed on newly collected serum and that which had been stored for 13–14 years. Skin testing was also performed. The results remain positive and suggest a degree of allergy to all the neuromuscular blockers with the possible exception of vecuronium. The radio-allergosorbent test was negative in the patient's baby.

Key words

Allergy; radio-allergosorbent test.

Neuromuscular relaxants; suxamethonium.

Case history

A 20-year-old obstetric patient with a history of allergic reaction to suxamethonium was referred from the antenatal clinic at 36 weeks' gestation in her first pregnancy, which was proceeding normally. It appeared from her hospital notes that at the age of 7 she had had an anaphylactic reaction, after induction of anaesthesia for an ENT operation. Premedication with trimeprazine was followed by thiopentone and suxamethonium, when she developed bradycardia, cyanosis and bronchospasm, with circulatory collapse. She was successfully resuscitated with compound sodium lactate solution, hydrocortisone and atropine, and the operation abandoned.

Some months later it was decided to re-admit her to hospital for the same operation and with the same anaesthetic technique. She showed no reaction to thiopentone, but after suxamethonium 30 mg gave a few convulsive twitches and rapidly started to 'go off colour'. Halothane 1% was also given. Examination under anaesthetic and bilateral myringotomy was performed, but it was decided not to proceed to adenoidectomy as she became virtually pulseless and was again resuscitated with intravenous fluids and oxygen. She was transferred to the Intensive Therapy

Unit for observation since she remained cyanosed without added oxygen. There were no physical signs in the chest after a brief period of bronchospasm. She made a complete recovery and was referred for further investigation because the anaesthetist believed strongly that she was allergic to suxamethonium. She had had a previous anaesthetic for an ENT procedure at another hospital at the age of 5. The anaesthetic chart was not available but it was thought likely that she had received suxamethonium since this was the usual practice at that hospital.

A sample of blood was sent to University College London (UCL) for testing. A leucocyte challenge (histamine release)^{1,2} test was performed which showed a strong response (histamine release) to suxamethonium and no response to thiopentone (Table 1). Other tests suggested indirectly an allergic mechanism rather than a nonimmunologically mediated reaction (idiosyncrasy); the evidence included high histamine release with anti-IgE serum in the absence of other known allergies, and history of possible previous exposure without reaction. Total serum IgE (a nonspecific test for immediate-type allergy) was normal, but this is a common finding and does not exclude allergy.

The conclusion was that there was an allergy to suxa-

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Table 1. Leucocyte histamine release tests. Values expressed as mean (SEM).

Treatment	Concentration $\mu\text{g/ml}$	Percent histamine release					
		First test, December 1973		Second test, December 1974		Third and fourth tests, June 1987	
Control (buffer)	—	6.35	(0.95)	—	—	9.83	(0.57)
Suxamethonium	4	—	—	—	—	10.05	(0.32)
	10	46.69	(4.00)	—	—	—	—
	20	—	—	—	—	24.84	(0.45)
Tubocurarine	4	—	—	—	—	24.84	(0.64)
	10	—	—	9.39	(0.40)	—	—
	20	—	—	—	—	26.87	(0.36)
Gallamine	4	—	—	—	—	9.42	(0.50)
	10	—	—	3.57	(0.22)	—	—
	20	—	—	—	—	8.80	(0.40)
Pancuronium	4	—	—	—	—	7.58	(0.77)
	10	—	—	8.41	(0.68)	—	—
	20	—	—	—	—	10.99	(0.77)
Alcuronium	4	—	—	—	—	11.82	(0.78)
	10	—	—	5.59	(0.30)	—	—
	20	—	—	—	—	10.54	(0.50)
Atracurium	4	—	—	—	—	0*	(0.50)
	20	—	—	—	—	2.73	(0.80)
Vecuronium	4	—	—	—	—	9.59	(0.10)
	20	—	—	—	—	7.58	(0.77)
Others**	—	—	—	—	—	—	—

* High blank reading (fluorescence) subtracted, result difficult to interpret.

** In 1973 thiopentone gave a negative result, and anti-IgE caused substantial release.

methonium, but it was suggested that further leucocyte challenge tests should also be performed on the other neuromuscular blocking agents (NMB), since cross-reactivity may occur.^{2,3} A sample of blood was sent, but the results were mislaid and the patient was 'lost' until she re-appeared in the antenatal clinic some 14 years later.

Management

The patient was then at 36 weeks' gestation so it was not possible to arrange further allergy testing until after delivery. The patient was obviously a risk for general anaesthesia and it was agreed that local or regional techniques should be used in preference in the meantime.

She went into labour spontaneously at term and epidural anaesthesia was performed using bupivacaine. She was also given cimetidine and kept well hydrated, with intravenous fluids. Fortunately she had a normal labour and delivery and there were no complications.

Arrangements were made after delivery to perform further allergy testing against all the muscle relaxant agents now available, that is suxamethonium, gallamine, tubocurarine, pancuronium, alcuronium, atracurium and vecuronium. Blood was collected for the leucocyte histamine release tests (two) required to cover all those agents in a quantitative way (with replicates of two or three concentrations of each agent).⁴ This test is an *in-vitro* correlate of anaphylactic and anaphylactoid reactions.^{5,6} Quantitative skin tests, which had not been performed previously, were also carried out.

The stored serum specimens (frozen at -60°C) and the results of the tests which had been performed some 13 and 14 years previously, were traced at UCL. A new test was

also performed; this is a radio-allergosorbent test (RAST, collaborative project with Pharmacia Ltd) which detects specific IgE antibodies against the haptenic determinant common to all neuromuscular blockers (NMB), the quaternary ammonium group.^{3,6,7} This test was performed on the stored as well as the new sample from the patient, and on the patient's baby daughter at the age of 15 months.

Results and discussion

Results of the leucocyte histamine release tests are summarised in Table 1. They were initially strongly positive with suxamethonium, with smaller histamine release with tubocurarine, gallamine, pancuronium and alcuronium. The response (histamine release above control level) declined over the 13–14 year follow-up, with the exception of tubocurarine, but overall the results are still positive.

The RAST for allergen-specific IgE antibodies (which are relatively labile compared with other classes of antibodies) was performed on serum samples which had been stored for 13–14 years, but the results are still clearly positive as indicated by a high ratio/upper limit of normal (Table 2). In strict terms, the most recent of all sera is negative because the ratio is < 2 , which is an arbitrary cut-off. However, with the well established history and the currently positive leucocyte histamine release test, there is no doubt that the patient would be susceptible to reactions to NMB. She was presumably sensitised through her first anaesthetic at the age of 5. At no time was the total serum IgE above normal. Serum from the patient's baby daughter gave a negative RAST. The value of RAST is beyond any doubt, although the demarcation between normal and allergic subjects may not be clear-cut and extensive studies are

Table 2. Total and allergen (quaternary ammonium group)-specific IgE in serum.

Date	Total IgE KU/litre	Allergen specific IgE***: RAST (ratio/upper limit of normal)
December 1973	51.7* (N)	5.83 ± 0.10
December 1974		4.23 ± 0.15
June 1987	25.0** (N)	1.53 ± 0.03

* Radioimmunosorbent (RIST).
 ** Paper RIST (PRIST).
 *** Radio-allergosorbent test (RAST), all carried out in November 1987 on stored (frozen) serum.
 N, normal.

needed to establish the dividing line. In the common allergies caused by inhalants low levels of allergen-specific IgE are usually ignored, but slightly different criteria are considered in penicilloyl RAST. Only a few RAST kits for drug allergies are commercially available: one of these is penicilloyl RAST with two variants only, one for penicillin G and another for penicillin V. For NMB there is only one for the quaternary ammonium, and thus the degree of specificity or extent of cross-reaction in individual patients (which varies considerably)³ cannot be investigated directly, a facility which is offered by the leucocyte histamine release test.

The skin test which was performed recently (Fig. 1) may

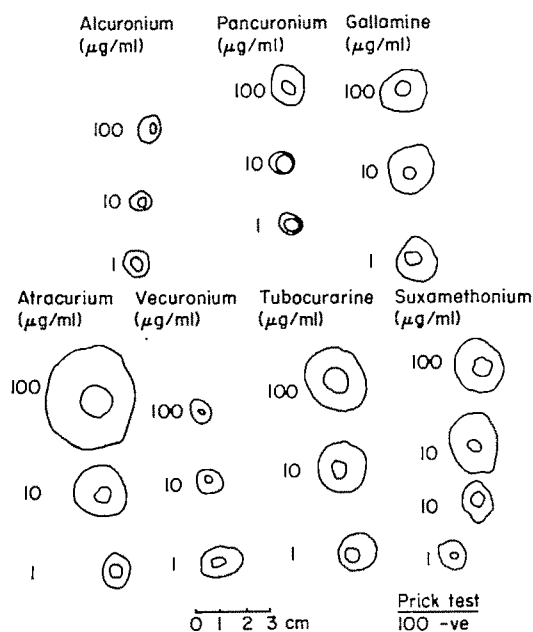


Fig. 1. The result of the intradermal skin test. Concentrations of each drug (µg/ml) in phosphate-buffered saline pH 7.4 are given, and size of wheal (centre) and surrounding flare areas are outlined. The volume injected was 0.025 ml.

be considered as positive, but in the area of reactions to NMB its value is somewhat controversial; some workers advocate its usefulness⁸ while others have reservations.⁹⁻¹² It has limitations and is not reliable in respiratory allergies that result from the common inhalant allergens, such as pollens and house dust mites. One of the main causes of limited reliability is the frequent occurrence of false positives.^{3,10}

Anaphylactic (where there is evidence of mediation by IgE

antibodies) and anaphylactoid (where such evidence is lacking) reactions to NMB are often undiagnosed.¹³ Furthermore, *in-vitro* testing for anaphylactic or anaphylactoid reactions are available only in a limited number of institutions, and are rarely covered from NHS funds. These tests, which were performed in our patient outside the NHS, were all very time consuming and expensive (particularly the leucocyte histamine release test) and we had to make out a strong case in order to obtain agreement for funding.

It was decided, mainly on the basis of the leucocyte histamine release and skin tests in this patient, and partly on account of the chemical structure, published literature¹⁴ and our experience, to issue the patient with a Medic-Alert bracelet to warn against future use of NMB, with the possible exception of vecuronium which has a single quaternary ammonium group. In general, for NMB to elicit histamine release *in-vitro*, at least two such groups are needed in the structure.³ However, clinical reactions to vecuronium have been reported,¹⁵⁻¹⁹ and in some patients *in-vitro* basophil histamine may be elicited with the same agent (unpublished observation). It should be added that the second nitrogen in vecuronium is tertiary, but because of its high pKa (8.97, information from Organon, the manufacturer) it becomes almost completely protonated at physiological pH; the drug will then carry two positively charged groups. Tubocurarine is also a monoquaternary compound, with a second nitrogen which is tertiary and is completely protonated at pH 7.4. This gives the molecule two strongly positively charged centres²⁰ and in some patients the protonated tertiary nitrogen of either of these two NMB may have binding affinity to IgE antibodies on blood basophils and tissue mast cells, thus the drug cross-links IgE molecules and triggers histamine release.

To our knowledge this is the youngest known case of allergy to suxamethonium and the longest follow-up.

Acknowledgments

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CASE REPORT

Major thoracic surgery during active tetanus

P. A. FARLING, T. D. E. SHARPE AND R. C. GRAY

Summary

This report describes the anaesthetic and intensive care management of a patient who had a thoracotomy during active tetanus. The dilemmas which faced the clinicians involved with the case are discussed.

Key words

Infection; tetanus.

Surgery; thoracotomy.

Tetanus is now a rare disease in the Western world.¹ This unit, which is the regional referral intensive care unit for Northern Ireland, has seen only three cases in 4 years. We report a case in which a patient required major surgery during active tetanus, a combination of events which has not been reported previously, and discuss the clinical dilemmas which were encountered.

Case history

A 47-year-old female, in apparent good health, attended her local district general hospital with troublesome varicose veins. They had been injected previously, but had become increasingly painful over the past 8 years with ulcer formation. Arrangements were made for admission for bilateral ligation of varicose veins. Pre-operative questioning and examination were unremarkable, but her pre-operative chest X ray showed a mass in the right hilum suggestive of bronchial carcinoma. The decision was made to proceed with the varicose vein surgery while further investigation of the hilar mass was made. A specimen of sputum was obtained and sent for cytological examination at induction of anaesthesia.

Her progress was uneventful until the fifth postoperative day when she complained of difficulty in opening her mouth. This progressed rapidly to marked trismus. She also experienced difficulty in swallowing and clearing secretions, and moderate neck stiffness was noted. Her temperature remained normal and her level of consciousness was not affected. A consultant anaesthetist in the district general hospital made the presumptive diagnosis of tetanus and she was transferred to the Intensive Care Unit of The Royal Victoria Hospital, Belfast.

She was unable to open her mouth or flex her neck on admission, but could move her head a small amount from side to side. There was no excessive salivation or swelling around the jaw. Power, tone and movement were normal in all limbs. Anaesthesia was induced with nitrous oxide, oxygen and isoflurane in order to investigate other possible causes of trismus. This produced good relaxation of the mandible with no residual masseter spasm. Throat swabs were taken and a dental registrar examined the teeth but found no intra-oral disease.

Trismus returned later that afternoon and she became very distressed after taking a sip of water. Her neck was now extended and increased muscle tone in the abdominal muscles developed into painful muscle spasms. She was kept under close observation but further spasms associated with cyanosis necessitated sedation, relaxation, intubation of the trachea and assisted ventilation. Treatment included the administration of antitetanus serum, tetanus toxoid, penicillin and adequate hydration. Cardiovascular instability was managed by bolus injections of labetalol,² digoxin and methyl-dopa. Later an infusion of labetalol provided better control of the overactivity of the sympathetic nervous system.^{3,4}

Bronchoscopy was performed through the tracheostomy, as the sputum cytology indicated malignant cells in keeping with adenocarcinoma, but no lesion of the trachea, major bronchi or lobar bronchi was detected. Computerised tomography of the mediastinum showed excess tissue around the right main bronchus, but this was thought to be as a result of hypostatic pneumonia in the lower lobes, and the extent of the lesion could not be determined. Thoracotomy and lobectomy was planned with much discussion on the timing of surgery since the patient still suffered

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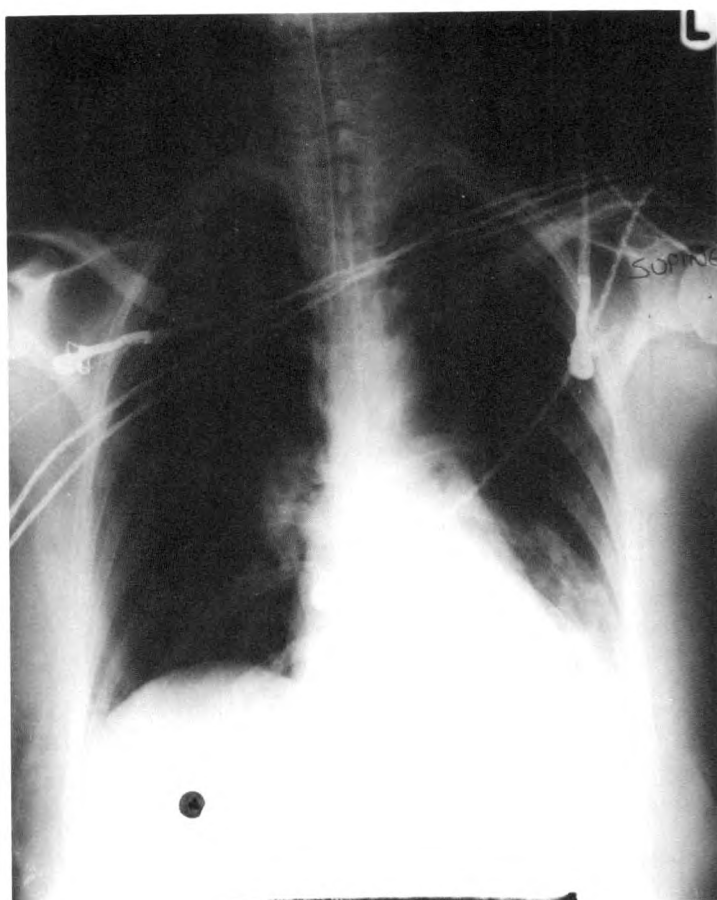


Fig. 1. Chest X ray showing hilar mass.

from active tetanus with marked cardiovascular instability. Postoperative management was also discussed at some length, particularly the effect of long-term positive pressure ventilation on the bronchial stump after lobectomy or pneumonectomy, because therapy for tetanus still necessitated the use of muscle relaxants.

Thoracotomy was eventually undertaken and anaesthesia consisted of nitrous oxide, oxygen, isoflurane, levorphanol 2 mg and pancuronium 8 mg, with double-lumen bronchial intubation. There was no evidence of any pulmonary neoplasm and lymph nodes biopsied and sent for frozen section suggested a diagnosis of sarcoidosis.

The chest X ray showed left lower lobe collapse when she returned to intensive care postoperatively. This responded to physiotherapy and suction through a fiberoptic bronchoscope. The immediate postoperative course was further complicated by haemorrhage and emergency thoracotomy was required to control severe bleeding from aberrant bronchial arteries.

Recovery from both the thoracotomy and tetanus was slow but otherwise uneventful with gradual weaning from muscle relaxants, sedation and parenteral nutrition. The pathology report confirmed epithelioid granulomatous infiltration in keeping with sarcoidosis, and no malignancy. Tuberculin testing was negative, angiotensin converting enzyme was within normal limits and a Kviem test was performed.

She returned to the Intensive Care Unit of the district general hospital after 84 days in the Royal Victoria

Hospital to continue rehabilitation, convalescence and physiotherapy.

Discussion

The cause of this patient's tetanus was never fully explained. There was no obvious wound, except that which resulted from the varicose vein surgery, and despite extensive microbiological investigation of the theatres in the district general hospital, no *Clostridium tetani* organisms were ever detected. Most recent reports of postoperative tetanus have followed cholecystectomy.⁵⁻⁷ The relatives were able to confirm that she was not a gardener and that she had not been vaccinated since school days. It is possible that the varicose ulcer was the site of entry of the organism, but she may be classified in the 10% of patients in which no cause is ever found.¹

The timing of the procedure was crucial once it was established that a thoracotomy was required. Should the procedure wait until the tetanus had resolved, or would delay allow an operable tumour to become inoperable? What effect would surgery and anaesthesia have on a patient with tetanus, especially in the presence of cardiovascular instability? It was considered, both by the clinicians involved and by the relatives, that the patient should not be allowed to recover from tetanus only to discover that she then had to undergo major chest surgery.

The problems in the postoperative period were expected to depend upon whether the tumour could be removed

adequately by lobectomy or pneumonectomy. Ventilation would still be required and since low inflation pressure on the bronchial stump would be desirable, both high frequency jet ventilation⁸ and differential lung ventilation,⁹ were considered. The patient returned to conventional intermittent mandatory ventilation (IMV) since, in the event, no major lung resection was actually required.

The differential diagnosis of the hilar lymphadenopathy included sarcoidosis, tuberculosis and an inflammatory response to neoplasm or infection. There appears to be no link between the lymphadenopathy and the onset of tetanus. There was no systemic manifestation of either sarcoid or TB and no tumour was found at thoracotomy. Careful follow-up of this patient is obviously mandatory.

In conclusion, this case illustrates that with inter-specialty planning and careful anaesthesia, major surgery can be performed in patients suffering from active tetanus.

Acknowledgments

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gratefully acknowledged. The tireless work of the nursing, technical and physiotherapy staff of the Royal Victoria Hospital Intensive Care Unit is recognised and finally, thanks are also due to Mrs S. Roy for secretarial help.

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CASE REPORT

Angiotensin II in the management of excision of phaeochromocytoma

K. J. SOMMERVILLE AND J. B. M. MCKELLAR

Summary

The management of a patient with an unusual combination of anaesthetic problems, namely phaeochromocytoma and difficult intubation is described. Angiotensin II is discussed in the management of hypotension after excision of the tumour.

Key words

Enzymes; angiotensin II.

Surgery; endocrine, phaeochromocytoma.

Angiotensin II is a naturally occurring octapeptide with a plasma half-life of 1–2 minutes. It is a powerful vaso-constrictor produced by the breakdown of angiotensin I by a converting enzyme. This report describes its use in the management of hypotension after excision of a phaeochromocytoma.

Case history

A 25-year-old man presented to this department for excision of a phaeochromocytoma. His history was unusual in that while on holiday abroad he was shot in the neck and sustained a fractured mandible. He had an episode of severe hypertension while undergoing surgery for reduction and fixation of the mandible. He survived the procedure and underwent extensive investigations which confirmed raised circulating catecholamine levels with a CT scan that showed a mass at the upper pole of the right kidney.

Treatment was started on a combination of phenoxybenzamine 30 mg daily and atenolol 100 mg and he returned to this country. He underwent further testing at this hospital which revealed consistently elevated serum nor-adrenaline at 22–45 (normal 0–5) nmol/litre with correspondingly raised levels of urinary metabolites, normet-adrenaline 30.8 (normal 1.7–5.0) mmol/24 hours and VMA 86 (normal 9–35) mmol/24 hours. The patient was asymptomatic on presentation, his blood pressure was 120/85 mmHg, pulse rate 60 and resting ECG was normal. The major abnormalities were that of a Horner's Syndrome on the side of the injury and jaw opening was severely limited as a result of destruction of the temporomandibular joint.

Method

Institutional approval and informed consent were received, after which the patient was premedicated with papaveretum

20 mg and hyoscine 400 µg; his antihypertensives were maintained until the evening before operation. He was brought to the anaesthetic room where venous access was established. ECG monitoring using CM5 leads and indirect blood pressure monitoring by way of an automatic oscillometer were instituted. Previous discussion with the patient revealed that he would not accept any form of awake tracheal intubation so light general anaesthesia was induced with a small dose of thiopentone and it was established that the airway could be maintained with an Ambu facemask. Anaesthesia was then deepened with N₂O, oxygen and ether until laryngoscopy was possible. Jaw opening remained almost nonexistent so he was intubated by the blind nasal method and breathed spontaneously.

He was then transferred to theatre where anaesthetic maintenance was changed to isoflurane. Direct arterial monitoring was established and a right internal jugular line was inserted for central venous pressure measurement (CVP) and to provide access for vaso-active drugs. Relaxation was provided by boluses of alcuronium and analgesia by papaveretum as required. Control of systolic blood pressure was achieved by titration of the inspired concentration of isoflurane into a high flow system.

The inspired isoflurane concentration was reduced to 0.5% and an infusion of angiotensin II in 5% dextrose through a volumetric infusion pump was started after removal of the tumour. Again, this was titrated to maintain blood pressure at a steady level. Blood loss was very little and fluid replacement consisted of compound sodium lactate solution administered in order to maintain a reasonable CVP and urine output.

Residual paralysis was reversed at the end of the procedure with neostigmine and glycopyrronium and the tracheal tube removed when the patient was fully awake. He was transferred to ITU for continuation of the invasive cardiovascular monitoring. The angiotensin infusion was tem-

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porarily stopped during transfer caused by pump failure and on his arrival the blood pressure had decreased markedly to 60/35 mmHg, but was restored to normal on restarting the infusion which was gradually titrated down from 0.66 μ g/minute to zero. He returned to the surgical ward the next day.

Discussion

The perioperative management of phaeochromocytoma has been reviewed in a number of articles¹ with opinions varying from that of the technique chosen having no relevance to outcome² to that where technique is crucial.³ The main factors involved are stabilisation of blood pressure pre-operatively with combined alpha- and beta-blockade and avoidance of ventricular tachyarrhythmias intra-operatively. In addition there is often the problem of post-excisional hypotension in the hours immediately after surgery. This latter phenomenon occurs largely as a result of the reduction in circulating catecholamine levels but is also partly due to the concomitant hypovolaemia and continuing alpha- and beta-blockade. The hypovolaemia is easily corrected with crystalloid or colloid fluid replacement but a number of different agents have been used to 'wean' the cardiovascular system back to normality. Drugs such as dopamine, dobutamine, isoprenaline and ephedrine have a number of disadvantages that include tachycardia and tachyphylaxis and it occurred to us that another agent may be more desirable.

Our department of Materia Medica have for some years used angiotensin II as a research tool⁴ to initiate non-adrenergic vasoconstriction in order to provide hypertension in human volunteers. They suggested that the agent may have advantages after excision since it provides a means of nonadrenergic vasoconstriction and possibly allows a more rapid return of normal adrenergic control.

Angiotensin II is a naturally occurring octapeptide produced by enzymatic breakdown of angiotensin I by angiotensin converting enzyme (ACE). It has a plasma half-life of 1–2 minutes, and is converted by aminopeptidases to angiotensin III and inactive metabolites. It is the most powerful vasoconstrictor known, four times as powerful as noradrenaline on a weight basis and exerts its effect through receptors in arterial walls. Other important actions are on peripheral noradrenergic neurones to promote the synthesis and release of catecholamines; a central pressor effect in the area postrema; and on the subfornical organ and organum vasculosum of the lamina terminalis to increase water intake and vasopressin secretion. Aldosterone production is increased by its action on the adrenal cortex in addition to that of angiotensin III.

This drug therefore can increase blood pressure rapidly in a controllable fashion because of its short half-life, has no associated tachycardia or tachyphylaxis, and has possible useful longer term effects due to its central and adrenocortical effects. It is provided in ampoules that contain 2.5 mg of the drug as a powder and the recommended technique

of administration is by controlled infusion made up to a volume of 100 to 1000 ml of 5% dextrose, normal saline or other physiological solutions and at a rate between 1 and 20 μ g/minute as required.

The choice of volatile anaesthetic in this case was dictated by a number of factors. The author's (J. McK.) preferred method of management of a very difficult tracheal intubation is by the blind nasal route. The only two agents which provide deep anaesthesia combined with a prolonged duration of action (allowing more time between applications of a facemask) are halothane and diethyl-ether. Halothane however is known to sensitise the myocardium to catecholamines, and in addition the patient had undergone halothane anaesthesia in the past, which some now take to be a relative contraindication to use. Ether, although rarely used nowadays, does not cause cardiac arrhythmias and does not sensitise the myocardium to catecholamines.^{5,6} It allowed an ideal amount of time to attempt tracheal intubation because of its high blood-gas solubility. Care was taken to remind the theatre staff of the unusual explosion risk.

Isoflurane has been suggested as the ideal volatile agent in phaeochromocytoma surgery because of its lack of myocardial sensitisation to catecholamines and nitroprusside-like effect to facilitate control of blood-pressure.³ Blood pressure throughout the event was for the most part very well controlled.

In conclusion, angiotensin II is a powerful and versatile agent with strikingly few side effects compared with current alternatives and appears to have a place in the management of phaeochromocytoma surgery and other situations where a pure vasoconstrictor is required.

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CASE REPORT

Epidural anaesthesia for bilateral inguinal herniorrhaphy in Eisenmenger's syndrome

D. S. SELSBY AND J. C. SUGDEN

Summary

The successful management of a patient with Eisenmenger's syndrome undergoing bilateral herniorrhaphy is described, and some of the anaesthetic problems associated with this condition are considered. The case is reported because epidural anaesthesia is performed rarely in these patients. The use of subcutaneous heparin, the level of monitoring required, and the value of pulse oximetry are also discussed.

Key words

*Anaesthetic techniques, regional; epidural.
Complications; Eisenmenger's syndrome.*

In 1958 Wood¹ defined Eisenmenger's syndrome as 'pulmonary hypertension at or close to systemic level with reversed or bidirectional shunting at aortopulmonary, ventricular, or atrial level'. The condition is rare, but patients may survive into their 4th or 5th decades² and require anaesthetic management for incidental surgery. Patients have been managed successfully with general anaesthesia and several authors^{3–5} have advocated this in preference to epidural blockade for lower abdominal or lower limb surgery. However, the peri-operative mortality rate remains high,⁴ and especially in labour with a maternal mortality of about 30% during vaginal delivery^{6–7} and up to 75% after Caesarean section.⁷

Epidural anaesthesia has been employed in only a few cases^{8–10} because of the possible adverse effects on the systemic vascular resistance and hence the size of the shunt, but there were no significant complications in these patients. We report a further case managed successfully with epidural anaesthesia to highlight the problems associated with this condition and to discuss the level of monitoring required.

Case history

A 43-year-old male patient was admitted for elective bilateral inguinal herniorrhaphy. Eisenmenger's syndrome had been confirmed at the age of 16 years by catheter studies which demonstrated a large ventricular septal defect (VSD) with equalisation of pressures between the pulmonary and systemic circulations. He was leading an active life at this time and complained of shortness of breath only when he

walked up hills. He was reviewed in 1977 as a result of increasing dyspnoea when secondary polycythaemia with a packed cell volume of 0.65 was noted and treated by intermittent venesections. He was admitted with a chest infection and right-sided heart failure from which he made a good recovery in 1983. However, 2 days after discharge he was re-admitted with distended nonpulsatile right-sided neck veins and a swollen and discoloured right arm. Angiography demonstrated right subclavian and brachiocephalic vein thrombosis which was successfully treated with anticoagulant therapy. Warfarin was discontinued 3 months later and subsequently the patient remained well.

He became breathless on walking upstairs or about 100 yards on the flat during his present admission. Examination showed he was cyanosed with finger clubbing and the jugular venous pulse was slightly elevated with a prominent 'a' wave, but there were no signs of peripheral oedema. Blood pressure was 160/90 mmHg, pulse rate 84 beats/minute, in sinus rhythm with occasional extrasystoles, and there was clinical evidence of both left and right ventricular hypertrophy. On auscultation the dominant signs were a first heart sound, an ejection click, a pulmonary ejection systolic murmur, a second sound and an early diastolic murmur at the left sternal edge. The ECG showed sinus rhythm with right bundle branch block and the chest X ray revealed an enlarged heart with very large proximal pulmonary arteries and pulmonary conus. Laboratory investigations reported a haemoglobin concentration of 180 g/litre, PCV 0.61, platelets 187, sodium 140 mmol/litre, and potassium 4.1 mmol/litre. Prophylactic antibiotics and sub-

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cutaneous heparin were prescribed and papaveretum 10 mg with hyoscine 0.2 mg were administered intramuscularly one hour pre-operatively.

The patient was monitored in the anaesthetic room with an automated blood pressure cuff set to cycle every 3 minutes, an ECG, and a pulse oximeter. Baseline values were arterial blood pressure 135/70 mmHg, pulse rate 80 beats/minute with sinus rhythm, and oxygen saturation (SaO_2) 85% on air. Oxygen was then administered by an MC mask at 6 litres/minute, which increased the SaO_2 to 93%. Compound sodium lactate solution was started slowly through a large bore intravenous cannula and a midline epidural was performed in the left lateral position at the $\text{L}_{2/3}$ interspace. An 18-gauge catheter was sited 3 cm into the epidural space and a test dose of 3 ml 1.5% plain lignocaine was followed 5 minutes later with 14 ml 0.5% plain bupivacaine whilst the patient remained in the left lateral position. This was done because the left hernia was much larger than the right, and it was intended to repair the second side only if there were no complications. Fifteen minutes after the test dose, sensory blocks to T_{10} on the left and L_1 on the right side were noted; he was placed supine and a further 5 ml 0.5% bupivacaine administered. The patient was also sedated with 10 mg of intravenous Diazemuls.

At 30 minutes a bilateral sensory block to T_8 was demonstrated and the patient was prepared for surgery. The blood pressure and SaO_2 remained stable until this point, but then started to decrease gradually over the next 10 minutes to 104/60 mmHg and 89% respectively. Initial management was to place the patient in a 10° head down position. This together with the start of surgery, increased the arterial pressure to 120/60 mmHg and the SaO_2 to 91%; these values were maintained for the rest of the operation. Surgery lasted 45 minutes, both herniae were repaired with little blood loss, and only 500 ml of compound sodium lactate solution was transfused. Postoperatively the patient was kept on oxygen therapy for 2 hours, encouraged to mobilise early, and made an excellent recovery with no complications.

Discussion

Management of the patient with Eisenmenger's syndrome includes the prevention of dehydration, hypovolaemia, and decreases in systemic vascular resistance, all of which may lead to systemic hypotension and an increase in the right to left shunt. Hypercapnia and hypoxia are also hazardous as they may increase pulmonary vascular resistance and again exacerbate this shunt. General anaesthesia is advocated for these patients³⁻⁵ mainly because of the fear of severe and sudden decreases in systemic vascular resistance following blockade of sympathetic nerve fibres. However, both techniques can affect adversely the haemodynamic status of these patients, and previous case reports that employed epidural anaesthesia for tubal ligation,⁸ Caesarean section,⁹ and labour¹⁰ have demonstrated it to be a viable alternative to general anaesthesia. Furthermore, since both the pathophysiology of Eisenmenger's syndrome and the effects of epidural anaesthesia are well known, problems can be anticipated and treated rapidly, whereas during general anaesthesia the reasons for hypotension or increasing hypoxia may be more diverse.

Dehydration in this case was prevented because the patient was allowed free fluids until 4 hours before surgery and

further hypoxia was avoided by increasing the inspired oxygen peri-operatively. Blood loss was slight, and hypotension minimised because incremental doses of local anaesthetic were used to control the block to T_8 . The subsequent decrease in arterial pressure to 104/60 mmHg 30 minutes after the test dose, responded to either the start of surgery or the head down position. Phenylephrine would have been used to increase the systemic vascular resistance if the blood pressure had continued to decrease. However, the value of this therapy has not been fully proven¹¹ and theoretically it could worsen the hypoxaemia by decreasing tissue perfusion and further desaturating venous blood.¹²

Other complications associated with Eisenmenger's syndrome include thrombosis as a result of the polycythaemia, air embolus, and infective endocarditis. The risks of these problems were minimised in this case because the patient was managed with noninvasive monitoring, and also by prophylactic antibiotics and heparin. The level of monitoring required in these patients is controversial,⁵ with advocates of both noninvasive⁴ and totally invasive techniques.⁷ Direct arterial readings would have given continuous arterial pressure values in this patient, but not the display of continuous SaO_2 which was obtainable with the pulse oximeter and served as an indirect guide to shunt changes. Transcutaneous oxygen probes have been used in other case studies^{13,14} for the same reason, and monitor oxygen tension instead of SaO_2 .

Authors' opinions also differ about the need for pulmonary artery catheterisation; some consider their use essential in every patient,⁷ whereas others believe that the risks strongly outweigh the benefits in all cases.¹⁵ The main complications include arrhythmias, pulmonary artery rupture,¹⁶ thrombosis¹⁷ and embolisation, and we agree with Foster and Jones⁵ that patients may benefit only in cases of aortopulmonary shunts or small atrial septal defects. In cases of ventricular or large atrial septal defects, the pulmonary wedge pressure may not reflect the left ventricular filling pressures, and central venous pressure may be of more use especially as the right ventricle is at the greatest risk of dysfunction. Central venous pressure measurement was indicated in this case to maintain stable filling pressures in the presence of vasodilatation caused by the epidural, but it was not employed because of the patient's history of subclavian and brachiocephalic vein thrombosis.

Several authors¹⁸⁻²⁰ consider that epidural blockade is contraindicated in anticoagulated patients, but the use of low dose heparin before epidural anaesthesia is an issue which remains unresolved. The incidence of epidural haematoma formation after pre-operative subcutaneous heparin is unknown and in a recent review Owens *et al.*²¹ could not recall any case reports. Furthermore, in a study of 1000 continuous epidurals in patients who received both oral anticoagulants and intra-operative heparin,²² no neurological complications were detected. Alleman *et al.*²³ were also unable to demonstrate any problems that suggested spinal haematoma formation in 187 patients given subcutaneous heparin before they underwent spinal or epidural anaesthesia. Therefore, pre-operative low dose heparin was warranted in this patient because of the history of thrombosis and persisting polycythaemia.

In conclusion, an epidural technique can be used successfully in Eisenmenger's syndrome for lower abdominal surgery, but care must be taken to avoid excessive blockade, dehydration, and hypoxaemia. Pulse oximetry was highly

informative and some form of continuous oxygen saturation or tension display is advisable in these patients.

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CASE REPORT

The tumour lysis syndrome

Intensive care aspects of paediatric oncology

D. N. STOKES

Summary

Tumour lysis syndrome occurs when chemotherapy is started in children who present with advanced lymphomas and leukaemias. Rapid cell lysis causes life-threatening metabolic derangements because of the release of intracellular potassium, phosphate and uric acid. An alkaline diuresis is commonly established before the start of chemotherapy to minimise uric acid and phosphate deposition within the kidney. Two cases are described where intravenous fluid loading resulted in acute pulmonary oedema, and the intensive care management of such cases is discussed. The improved outcome from increasingly aggressive chemotherapeutic regimens means that children with advanced tumours and organ failure may present for supportive therapy during the early stages of treatment. Close liaison between paediatric oncologists and intensive care staff is essential to establish admission criteria for patients at risk of these complications, and to define therapeutic end points in the event of multisystem failure.

Key words

*Intensive care; paediatric.
Cancer; tumour lysis syndrome.*

Children who present with advanced leukaemia and non-Hodgkin's lymphoma may develop life-threatening complications that require intensive care facilities in the early stages of management. Patients with large tumour loads may develop profound metabolic derangements when chemotherapy is started because of massive cell lysis and the consequences of potassium, phosphate and uric acid release.¹ Acute hyperkalaemia has caused cardiac arrest and death in patients with Burkitt lymphoma^{2,3} and acute lymphoblastic leukaemia.⁴ High plasma urate levels carry a risk of renal failure because of precipitation of filtered urate in the collecting ducts. Acute hyperphosphataemia^{5,6} may result in the calcium phosphate solubility product being exceeded. This will lead to the precipitation of calcium salts and cause hypocalcaemia and renal failure if renal tubular deposition of calcium phosphate occurs.⁷

It is desirable to establish an alkaline diuresis by fluid loading before the start of chemotherapy in order to reduce urate deposition in the kidney and enhance clearance of phosphates and urate. However, patients with renal or postrenal tumour involvement may suffer acute circulatory overload in response to the fluid challenge. Furthermore, bulky abdominal lymphomas associated with ascites may seriously compromise diaphragmatic excursion and cause a reduction in functional residual capacity and atelectasis. Acute pulmonary oedema is poorly tolerated in these patients and acute respiratory failure may develop rapidly

and require intermittent positive pressure ventilation (IPPV) and dialysis.

Case histories

First patient

A boy aged 3 years 6 months (weight 24 kg) was admitted with malaise and massive abdominal distension as the result of hepatomegaly and ascites. He was tachypnoeic with expiratory grunting, limited diaphragmatic excursion and a right-sided pleural effusion. A pleural aspirate contained lymphoblasts and cytogenetic studies on bone marrow aspirate revealed abnormalities characteristic of B-cell lymphoma, with clinical and radiological evidence of hepatic, mediastinal, pleural and pulmonary spread.

Intravenous fluids were started in an attempt to establish an alkaline diuresis but the urine output diminished progressively despite mannitol and frusemide, and pulmonary oedema supervened. Oxygen therapy was instituted through a nasal catheter, but transcutaneous oxygen saturation decreased below 90% with worsening respiratory distress, and IPPV was started after tracheal intubation. Papaveretum was infused at 0.05 mg/kg/hour for sedation and atracurium at 0.25 mg/kg/hour for neuromuscular blockade. Oxygenation was maintained with an inspired oxygen concentration of 60%, and 0.4 kPa of positive end expiratory pressure (PEEP)

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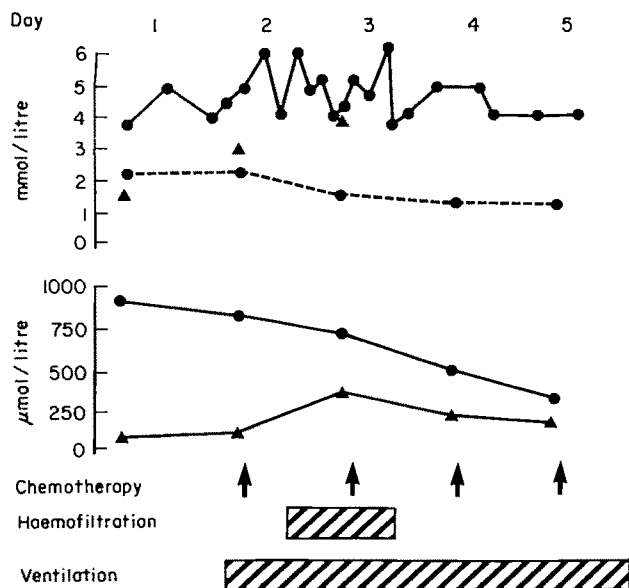


Fig. 1. Changes in serum potassium, calcium, phosphate, urate and creatinine in case 1. ●—● (top), K⁺; ●—●, Ca²⁺; ▲, phosphate; ●—● (below), urate; ▲—▲, creatinine.

at a ventilation rate of 30 breaths/minute. Arteriovenous haemofiltration was instituted by way of femoral arterial and venous cannulae to remove excess fluid, and serum potassium levels were controlled by an infusion of glucose and insulin (Fig. 1).

Chemotherapy was started with frequent serum potassium estimations sampled from an indwelling arterial line. Haemofiltration was successfully withdrawn after 48 hours, but 2 weeks elapsed before ventilation could be discontinued, by which time the pleural effusion and ascites had resolved. Parenteral nutrition was started and chemotherapy was continued on the Oncology Unit.

Extensive left lung consolidation, neutropenia and skin ulceration developed after 7 days, which required the patient's re-admission to the Intensive Care Unit. Despite mechanical ventilation, buffy coat transfusions and amphotericin therapy the patient died a week later of *Aspergillus fumigatus* pneumonia and septicæmia.

Second patient

A 6-year-old girl (weight 19 kg) was admitted with right loin pain and vomiting. She was pale with generalised lymphadenopathy, a right sided pleural effusion and a large irregular abdominal mass. A needle biopsy of the mass confirmed a diagnosis of B-cell non-Hodgkin's lymphoma (Burkitt-type).

Attempts to establish an alkaline diuresis resulted in a positive fluid balance of 1.4 litres despite mannitol and frusemide therapy. The patient was agitated and tachypnoeic with ascites, a right-sided pleural effusion and pulmonary oedema on admission to the Intensive Care Unit. The arterial oxygen tension rose from 7.6 kPa to 10.2 kPa with oxygen therapy, and sedation was achieved with small intravenous increments of midazolam. Chemotherapy was started and 400 ml of pleural fluid were aspirated at thoracocentesis. However, this procedure was followed by worsening respiratory distress that required nasotracheal intubation and controlled ventilation of the lungs. There was no radiographical evidence of pneumothorax or re-expansion

pulmonary oedema. Sedation was continued with a midazolam infusion supplemented with boluses of papaveretum, and neuromuscular blockade was achieved with a vecuronium infusion. There was a good tumour response to chemotherapy associated with a brisk diuresis, and mechanical ventilation was stopped within 24 hours. Serum potassium levels remained stable although serum phosphate levels rose to 6.8 mmol/litre (Fig. 2). The patient underwent uneventful insertion of a Hickman catheter 2 days later under general anaesthesia.

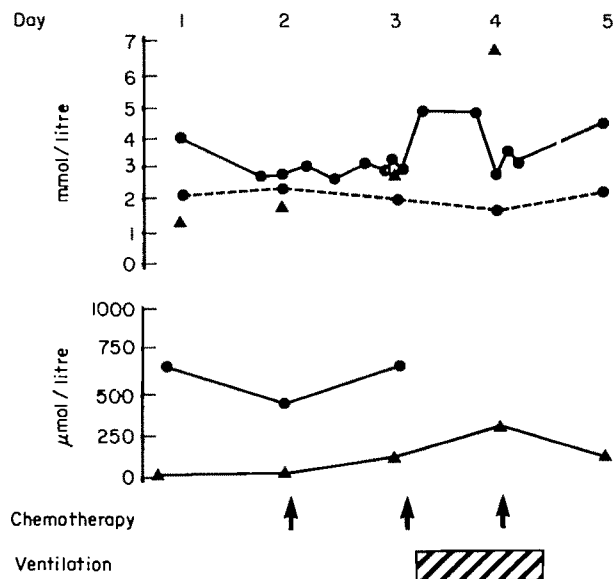


Fig. 2. Changes in serum potassium, calcium, phosphate, urate and creatinine in case 2. ●—● (top), K⁺; ●—●, Ca²⁺; ▲, phosphate; ●—● (below), urate; ▲—▲, creatinine.

Discussion

Chemotherapy effectively achieves remission in the majority of patients with acute lymphoblastic leukaemia and other lymphoproliferative malignancies. Burkitt-type non-Hodgkin's lymphoma, in which the growth fraction is 90–100%, may show extreme sensitivity to chemotherapy and result in major metabolic disturbances and renal failure, especially where tumour bulk is large and associated with pleural effusions and ascites.

A prechemotherapy strategy is implemented at Birmingham Children's Hospital to minimise the severity of the so called 'tumour lysis syndrome'. Following baseline biochemical investigations, an intravenous infusion of 0.45% saline in dextrose solution is started at a rate of 3 litres/sq m body surface area over 24 hours. Mannitol 1 g/kg and frusemide 2.5 mg/kg are administered intravenously to maintain a urine output above 100 ml/sq m/hour. The risk of urate deposition in the kidneys is reduced by urinary alkalisation with intravenous sodium bicarbonate adjusted to maintain urine pH between 7–7.5. Excess alkalisation may enhance urinary phosphate deposition. Oral aluminium hydroxide 5–10 ml 6 hourly is a useful phosphate binder under these circumstances if tolerated, and helps to prevent excessive rises in serum phosphate levels. Serum urate levels can be reduced with allopurinol 400 mg/sq m/day at the expense of hypoxanthine accumulation, and xanthine nephropathy has been reported.⁸

Worsening respiratory distress is likely to ensue, if a satisfactory diuresis cannot be achieved by the above measures, and early transfer to the Intensive Therapy Unit should be arranged for respiratory monitoring and therapy. Peritoneal or intravascular access may be secured to facilitate dialysis or haemofiltration to remove excess fluid and control rises in serum potassium.

The risk of life-threatening hyperkalaemia is greatest in the first 24 hours after the start of chemotherapy. Serum potassium is measured 3-hourly because early increases can be detected before the characteristic electrocardiographic features of hyperkalaemia are seen. An indwelling arterial cannula allows easy, reliable access for serial blood sampling and a potassium ion selective electrode in the ITU laboratory allows rapid measurement. Falsely high readings of serum potassium ('pseudohyperkalaemia')⁹ may be obtained if cell lysis occurs during sampling in the presence of greatly elevated white blood cell or platelet counts.

A serum potassium level above 6 mmol/litre is lowered by infusing 3 g/kg of glucose and 0.3 units of Actrapid insulin per kg over 10 minutes. Calcium resonium 1 g/kg is administered rectally and 0.3 ml/kg of 10% calcium gluconate intravenously to protect the myocardium from co-existent hypocalcaemia.

Incipient fluid overload may be monitored by clinical signs and central venous pressure monitoring should be reserved for difficult cases, since the risks of sepsis and haemorrhage after insertion of catheters may be considerable. Supportive measures for system failure should be instituted promptly during the early stages of chemotherapy.

Diaphragmatic splinting, from extensive abdominal tumour involvement with ascites, causes a reduction in functional residual capacity and an increase in respiratory energy expenditure. Extensive mediastinal lymph node involvement may cause compression of the major intrathoracic airways as well as reduce vital capacity, and pulmonary infiltrates and pleural effusions also reduce respiratory reserve. Pre-chemotherapy fluid overload will cause interstitial pulmonary oedema and a further reduction in pulmonary compliance which can rapidly precipitate respiratory failure.

Oxygen delivery can be monitored noninvasively by measuring transcutaneous oxygen saturation of haemoglobin with a pulse oximeter.¹⁰ This facilitates accurate oxygen therapy which is especially important in anaemic patients with reduced oxygen-carrying capacities.

Intermittent positive pressure ventilation should be instituted promptly in the event of impending exhaustion. Aseptic technique should be used for tracheal intubation through the oral route where possible. Nasal intubation may cause haemorrhage in the presence of thrombocytopenia, and sinusitis or purulent otitis media¹¹ can also develop. Ventilated patients may be sedated with midazolam (0.1–0.3 mg/kg/hour) and papaveretum (0.05 mg/kg/hour) by infusion, and muscle relaxation may be necessary in the early stages.

High inflation pressures and PEEP are usually necessary to maintain adequate gas exchange and the risk of pneumothorax should be borne in mind. Pleural effusions may be tapped without the insertion of underwater chest drains to avoid the risk of infection.

The administration of chemotherapy is seriously complicated by the development of acute renal failure with hyperkalaemia, electrolyte disturbances and fluid overload leading to pulmonary and cerebral oedema. Prerenal oliguria as a

result of dehydration and hypoalbuminaemia with loss of fluid into extravascular compartments should be corrected during prechemotherapy preparation. Renal impairment caused by direct tumour infiltration or postrenal ureteric obstruction by lymph node masses may necessitate short-term renal dialysis until tumour bulk has been reduced by chemotherapy. Haemodialysis or continuous arteriovenous haemo-ultrafiltration¹² may be preferable to peritoneal dialysis, which may cause diaphragmatic splinting and a further decrease in respiratory reserve. Phosphate binding and urinary alkalisation reduces the risks of calcium phosphate and urate deposition within the renal tubules and collecting ducts. Intermittent positive pressure ventilation may reduce urine output by lowering renal cortical blood flow. This in turn will release antidiuretic hormone and lower renal perfusion pressure by increasing inferior vena caval pressure.¹³

Metabolic encephalopathy can develop because of hyponatraemia and cerebral oedema and result in coma or status epilepticus with ataxic respiration and sudden apnoeas. Tracheal intubation and ventilation should be started in the event of inadequate airway protection or hypoventilation, to guarantee cerebral oxygenation and prevent hypercapnia. Cerebral perfusion pressure should be maintained and anticonvulsants administered as indicated. Nutrition should be maintained by the enteral route where possible, but claims that tumour response to chemotherapy may be enhanced by early parenteral nutrition¹⁴ have not been substantiated.

Haematological malignancies and myelotoxic cytotoxic agents result in serious bone marrow depression. Anaemia will require fresh blood transfusion and platelet concentrates should be available if thrombocytopenia results in haemorrhage. The neutropenia associated with intensive induction regimens leaves the patient at great risk of infection. Unexplained pyrexias should be thoroughly investigated with appropriate cultures, and treated promptly with broad spectrum antibiotics. The possibility of opportunistic nonbacterial infection should also be considered. Skin and mucous membranes provide an important barrier to micro-organisms which should be preserved by meticulous skin and mouth care. All invasive techniques, such as arterial and venous cannulations, tracheal intubation and toilet, and bladder catheterisation, should be undertaken with due regard for asepsis.

The continuing care of the gravely ill child imposes great psychological stress on staff and parents. Changes in the patient's condition and management decisions should be explained fully and without ambiguity. The decision to stop active treatment in a deteriorating case may be extremely difficult to take since the underlying tumour is often highly chemosensitive. Lloyd-Thomas *et al.*¹⁵ have suggested that continuation of intensive management may be inappropriate in adult patients if marrow function fails to recover after chemotherapy, especially after relapse and if the Apache II¹⁶ score is greater than 30.

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CASE REPORT

The use of flumazenil (Anexate, Ro 15–1788) in the management of drug overdose

B. J. POLLARD, A. P. MASTERS AND P. BUNTING

Summary

This is a report of a large selfadministered overdose of temazepam and meprobamate. The administration of flumazenil (Ro 15–1788) led to the partial antagonism of the depressant action of the drugs which was sufficient to avoid the need for invasive respiratory and cardiovascular support.

Key words

Antagonists; flumazenil.

Hypnotics; meprobamate, temazepam.

The management of patients admitted to hospital with acute self poisoning includes observation, monitoring, and support of vital functions until the likely drugs ingested are identified. Specific therapy may then be additionally indicated in order to counteract side effects, reduce toxicity or promote excretion.¹

Benzodiazepines are commonly prescribed and are a frequent component of self-administered drug overdoses. They are rarely fatal when they are the sole component of an overdose, although in the presence of other agents profound central depression may result.² Benzodiazepines have a large margin of safety and treatment is usually confined to continuing observation and support of vital functions.² It is likely that the recent availability of flumazenil, a specific benzodiazepine antagonist,³ will improve the management of these patients. The use of flumazenil in the management of an acute overdose, one component of which was a benzodiazepine, is described.

Case report

A 54-year-old man, found unconscious at home, was admitted to the Accident and Emergency Department. He had a long history of depression, had previously threatened to take an overdose and was found close to two empty containers labelled temazepam and meprobamate.

He was deeply unconscious on arrival in the Emergency Department with minimal response to painful stimuli. His breathing was slow and shallow; he had a blood pressure of 100/60 mmHg and was in sinus rhythm with a heart

rate of 84 beats/minute. He had no gag reflex and his trachea was intubated with ease. Gastric lavage was performed and tablet remnants were seen in the washings. A full examination revealed no other abnormalities, except for a rectal core temperature of 35°C. Naloxone 0.4 mg was given intravenously with no effect. His breathing had by this time become more shallow, and at a rate of 10 per minute. His blood pressure was measured at 60/40 mmHg and there was no response to deep pain. Arterial blood gas analysis revealed pH 7.34, PCO_2 6.3 kPa, PO_2 82.5 kPa and HCO_3 25.5 mmol/litre, on 100% oxygen from a T-piece.

Flumazenil (Ro 15–1788) 0.5 mg was given. Three minutes later his minute volume had increased (breathing was subjectively deeper at a rate of 14/minute) and his blood pressure had increased to 115/75 mmHg. There was now a weak flexor response to deep pain, a weak gag reflex and a cough reflex to tracheal suction. Repeat blood gas analysis showed that the PCO_2 had decreased to 4.9 kPa. A further dose of flumazenil 0.5 mg had no additional effect. He was transferred to the Intensive Care Unit.

His conscious level and ventilation slowly deteriorated so that 3 hours later he was again unresponsive to painful stimuli, although a weak cough reflex was still present. Blood gas analysis showed pH 7.28, PCO_2 7.6 kPa, PO_2 21.2 kPa, HCO_3 25.5 mmol/litre, on 50% oxygen via a T-piece. His tidal volume was 420 ml at a rate of 15/minute and his blood pressure 98/60 mmHg. A further 0.5 mg of flumazenil was given. His tidal volume rapidly increased to 680 ml at a rate of 15/minute, and decreased over the next 30 minutes to 540 ml at a rate of 15/minute. His PCO_2 at

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this time was 6.4 kPa. His blood pressure rose to 120/85 mmHg and he again became responsive to deep pain. A further 0.5 mg of flumazenil once again had no further effect.

His conscious level remained fairly constant from that point onwards, without any serious deterioration. His arterial PCO_2 increased again to 7.3 kPa after 4 hours, then slowly decreased, coincident with a slow, progressive improvement in his degree of arousal. Fourteen hours later (26 hours after his initial admission to the Accident and Emergency Department) he was responding to verbal stimuli and shortly after this was awake enough for his trachea to be extubated. Subsequent recovery was uneventful. The toxicology report confirmed the presence of temazepam and meprobamate. No other substance was detected.

Discussion

This report records a case where an attempt was made to treat a severe overdose, one component of which was presumed to be temazepam, with the new benzodiazepine antagonist flumazenil. This new agent, flumazenil, (Ro 15-1788, 'Anexate', Roche) is a benzodiazepine first described in 1981 by Hunkeler and colleagues.³ It is a specific antagonist with high affinity at the benzodiazepine receptor site⁴ and negligible agonist activity.⁵ Sedation or anaesthesia induced by a benzodiazepine is rapidly and completely reversed after the administration of flumazenil.^{6,7} It therefore follows that it might be of value in the treatment of a benzodiazepine overdose. This possibility has been considered previously and reports describe the use of flumazenil in the management of overdoses of benzodiazepines.^{8,9,10} It was shown to be most effective in cases where the sole drug ingested was a benzodiazepine, and resulted in rapid awakening.

Those previous observations are supported by this present report. A significant arousal was seen after the administration of flumazenil, although the patient still remained unconscious. This agrees with a benzodiazepine component of a mixed overdose. The half-life of flumazenil is approximately one hour¹¹ and so although the ingested drugs should be slowly undergoing elimination their action is likely to outlast that of a single bolus dose of flumazenil. A return to a deeper level of consciousness might then be expected, which should again be antagonised by a further dose of flumazenil, a feature which was observed. The use of a continuous infusion of flumazenil might have offered a convenient alternative. The profound unconsciousness, together with its associated hypotension and respiratory depression were each time improved by flumazenil and it is our belief that had flumazenil not been available, controlled ventilation and inotropic cardiovascular support would have been necessary.

It is clear therefore that flumazenil does antagonise the sedation caused by an overdose of temazepam. In the pres-

ence of another agent, however, only partial awakening is seen. Sufficient arousal may result, such that more invasive treatment may be avoided, even if there is not a full return to consciousness. It is likely that flumazenil will serve as a valuable diagnostic tool in overdoses of unknown composition, and allow identification of the presence of a benzodiazepine component. Care will have to be taken with the use of this new drug in the management of overdoses. It will still be necessary to admit the patient to an appropriate ward, where adequate monitoring and nursing supervision is present, whether or not the patient appears to be fully awake and orientated, because of the risk of the recurrence of sedation. Furthermore, all actions of a benzodiazepine are antagonised and if the patient is undergoing regular therapy with a benzodiazepine, e.g. for its anxiolytic or anticonvulsant effects, then these too will be antagonised. In addition, the sedative action of the benzodiazepine may be suppressing a more serious side effect of another component of the overdose. These problems should arise in only a minority of patients, however, and it is likely that the introduction of flumazenil will prove to be a valuable addition to our resources in the management of overdoses.

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Forum

Paediatric anaesthesia in a district general hospital

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Summary

Over 4000 general anaesthetics were administered during 1987 to children under the age of 13 years in the Norwich Health District. We have reviewed the 2938 anaesthetics performed in the Norfolk and Norwich Hospital. Five hundred and fifty-eight (19%) were undertaken in children aged less than 3 years; 24 of these were neonates. The implications of this workload are discussed, with reference to the more appropriate use of consultants with previous paediatric anaesthetic training, the training of junior staff and the policy for transfer of patients to specialised centres.

Key words

Anaesthesia; paediatric.

There is a paucity of published data on the organisational problems entailed in the provision of a paediatric service in a District General Hospital (DGH) in the United Kingdom. This was evident at the forum 'Paediatric Anaesthesia in the DGH' held by the Faculty of Anaesthetists at the Royal College of Surgeons of England in 1987 and is the subject of comment by Hatch.¹ We present data from the Norfolk and Norwich Hospital which is a large DGH in the East Anglia Region and which serves a population of approximately 470 000, of whom 70 000 are below the age of 13 years. There were 5301 deliveries in the District in 1987; 4517 births were in the maternity unit of the Norfolk and Norwich Hospital. The number of deliveries in the district has increased by an average of 1.3% per annum for the last 6 years. The East Anglia Region lacks a Regional paediatric hospital.

It is of historical interest that the Jenny Lind Infirmary for Sick Children was established in Norwich in 1853 and was not incorporated into the Norfolk and Norwich site until 1975.

The Jenny Lind Paediatric Department at the Norfolk and Norwich Hospital has 60 beds, 16 of which are in a ward that caters for children under the age of 2 years. In addition, there is a Special Care Nursery in the Maternity Block with 22 cots, of which four are funded by the Region for neonatal intensive care. The unit is managed by the paediatric department without involvement of anaesthetists. There were 324 admissions to the Special Care Nursery during 1987 with an overall mortality rate of 9%. Seventy-six patients required mechanical ventilation of the lungs. Fifty-two infants weighed less than 1.5 kg at birth and the mortality rate in this group was 23%.

Most of the surgery is conducted in a 10-theatre suite; one theatre is designated for paediatric use. There is a small paediatric reception room and a separate recovery area for children. The bulk of the elective surgery is done on child-

ren's operating lists (a fortunate legacy of the Jenny Lind Hospital). The major exception is orthopaedic surgery, which is performed in a separate suite of orthopaedic theatres on adult lists. Some of the paediatric work that involves the district anaesthetic department occurs at other sites in the county. All surgical specialties are represented except neurosurgery and open-heart surgery. There is no paediatric surgeon. There is also no specific consultant paediatric anaesthetist on-call rota.

Methods

The anaesthetic record books in the District for 1987 were reviewed and data collected for all children under 13 years (the admission age to the paediatric wards) who underwent general anaesthesia. The data from the Norfolk and Norwich Hospital were coded for date and type of procedure, surgical specialty, grade of surgeon, grade and name of the most senior anaesthetist present, age of the patient, whether or not performed in the designated paediatric theatre or on a paediatric list and if the procedure was a daytime (0800 to 2000 hours) or night-time (2000 to 0800 hours) emergency. In our coding for age we define neonates as of less than 44 weeks' gestation, infants as greater than 44 weeks' gestation but less than one year old, toddlers as greater than one year but less than 3 years old and children as greater than 3 but less than 13 years of age.

A questionnaire was sent to all the consultant anaesthetists in the department to obtain details of previous paediatric anaesthetic training.

Results

All results, unless stated otherwise, are based on data from the Norfolk and Norwich Hospital.

In 1987, 4108 general anaesthetics were performed on

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Table 1. The age distribution of patients under 13 years of age anaesthetised in 1987 and the grade of the most senior anaesthetist present.

Grade (number in department)	Neonate (< 44 weeks gestational age)	Infant (> neonate < 1 year)	Toddler (1-2 years)	Child (3-12 years)	All (< 13 years)
Consultant (n = 16)	20	138	225	1443	1826
Senior registrar (n = 2)	2	22	33	211	268
Registrar (n = 4)	2	8	54	262	326
Senior house officer (n = 7)	0	1	30	308	339
Other grades*	0	6	17	156	179
Total	24	175	359	2380	2938

* Includes clinical assistants, hospital practitioners and locum consultants.

Table 2. The age distribution by specialty.

	Neonate	Infant	Toddler	Child	Total
ENT	3	22	70	1124	1219
General surgery	15	86	65	299	465
Orthopaedics	0	5	58	272	335
Plastic surgery	0	41	58	218	317
Urology	0	6	29	260	295
Ophthalmology	0	4	22	109	135
Dental surgery	0	0	7	46	53
Medical	0	3	28	10	41
Radiology*	1	1	19	11	32
Thoracic surgery	5	6	1	17	29
Gynaecology	0	0	0	10	10
Cardiology	0	1	2	1	4
Casualty	0	0	0	3	3

* Includes radiotherapy.

patients aged less than 13 years in the District. Of these, 2938 (72%) were at the Norfolk and Norwich Hospital, 290 (7%) at other hospitals in the district and 880 (21%) at an outpatient dental clinic in Norwich. All outpatient dental anaesthetics were administered by consultants, as were 89% of all other anaesthetics outside the DGH. Two hundred and ninety other anaesthetics administered to children took place at sites where there are no paediatric wards.

The age distribution of the children and the grade of the most senior anaesthetist present are shown in Table 1. Seventy-one percent of all paediatric patients were anaesthetised in the presence of a consultant or senior registrar. This percentage rose to 79% for patients under 3 years and 91% for those under one year.

Table 2 shows the age distribution within specialties. Ear, nose and throat (ENT) procedures made up the largest group (41% of the total), but only 8% of these children were under 3 years of age. General surgery was the second largest group (16% of the total); 36% of these patients were aged less than 3 years and 22% less than one year. Anaesthetics for plastic and burns surgery made up 11% of all cases; 31% of these were infants and toddlers.

Theatre staff classified 413 (14%) of the anaesthetics as emergencies. Tables 3a and 3b show the age distribution of these emergency patients. A consultant or senior registrar anaesthetist was present for 44% of daytime emergencies and 26% of those after 2000 hours, but these percentages rose to 72% and 64% respectively for patients under 3 years. The majority of emergency paediatric work was in two specialties (orthopaedics, 38%; general surgery, 35%), but significant numbers and potential problems for the anaesthetist occurred in ENT and thoracic surgery.

Orthopaedic emergencies totalled 157 (nearly 50% of all their anaesthetics), of which 129 were for the treatment of fractures. There were 131 unscheduled, non-neonatal general surgical operations; the commonest was appendicectomy (84). Sixteen infants had an operation for pyloric stenosis and two for intussusception.

Ear, nose and throat cases made up the largest group of anaesthetics, but only 21 procedures were unscheduled; bleeding after tonsillectomy or adenoidectomy accounted for six cases. Seven patients required general anaesthesia for tracheal intubation in the management of croup or epiglottitis. Nine bronchoscopies were performed by the thoracic surgeons for inhaled foreign bodies.

Twenty-four anaesthetics were administered to 20 neonates (Table 4). The average weight of the neonates at the first operation was 3.0 kg (range 0.8-4.4 kg); the mean weight of four who underwent ligation of a patent ductus arteriosus (PDA) was 1.3 kg (range 0.8-1.8 kg). The paediatric theatre was used for only 12 of the 24 cases. A consultant or senior registrar administered 22 of the anaesthetics, but two cases for Ramstedt's procedure were daytime emergencies anaesthetised by postfellowship registrars. The two patients with gastroschisis (gestational ages 36 and 37 weeks; weights 2.4 and 2.3 kg respectively) underwent primary closure of the defect, although one had a bowel resection for a stricture at the initial operation. This patient required a further laparotomy and the formation of an ileostomy 20 days later for bowel obstruction; this was closed 2 months later. One baby aged 5 hours (gestational age 38 weeks; weight 3.5 kg) underwent a successful repair of a left diaphragmatic hernia and was discharged home on the 20th day. A term baby with Treacher-Collins syndrome (weight 3.7 kg) underwent an initial repair of choanal

Table 3a. The number of anaesthetic daytime emergencies (between 0800 and 2000 hours) administered by each grade of anaesthetist.

	Neonate	Infant	Toddler	Child	Total
Consultant	15	23	3	38	79
Senior registrar	0	6	3	17	26
Registrar	2	4	8	26	40
Senior house officer	0	0	5	85	90
Other grades	0	0	0	4	4
All	17	33	19	170	239

Table 3b. The number of anaesthetic night-time emergencies (between 2000 and 0800 hours) administered by each grade of anaesthetist.

	Neonate	Infant	Toddler	Child	Total
Consultant	1	4	3	15	23
Senior registrar	2	4	2	14	22
Registrar	0	3	4	18	25
Senior house officer	0	1	1	102	104
Other grades	0	0	0	0	0
All	3	12	10	149	174

Table 4. The diagnosis and number of anaesthetics in the neonatal period.

Diagnosis or operation	Number of patients	Number of anaesthetics
Closure of PDA	4	4
Pyloric stenosis	3	3
Strangulated or irreducible inguinal hernia	3	3
Incision of breast abscess	3	3
Gastroschisis	2	2
Ileostomy (gastroschisis)	—	1
Necrotising enterocolitis (closure of PDA)	—	1
Diaphragmatic hernia	1	1
Treacher-Collins syndrome, choanal atresia	1	3
Malrotation, small bowel obstruction	1	1
Sacrococcygeal teratoma, CT scan	1	1
Defunctioning colostomy, rectal biopsy	1	1
Total	20	24

atresia which required two further anaesthetics for replacement of the nasal splints. This baby underwent tracheostomy 3 months later for obstructive apnoeic episodes. All of the neonates were alive when their notes were reviewed in April 1988. Three of the patients were referred from a hospital in an adjacent district for ligation of patent ductus arteriosus (PDA). Seven neonates were referred to other hospitals (Table 5).

Of the 2525 elective cases, 2056 (81%) were anaesthetised on scheduled paediatric operating lists; 1580 (62%) of these were managed in the paediatric theatre. One hundred and seventy-nine (38%) of the 469 paediatric patients who had operations on adult lists underwent orthopaedic procedures. Table 6 shows that little use is made of the paediatric theatre for emergency work.

We know of three deaths in patients who had anaesthetics during the period of the survey. Two deaths were from acute lymphoblastic leukaemia; one had an anaesthetic 2 weeks before death for the administration of intrathecal methotrexate. The third patient died of an arachnoid cyst.

Table 5. Neonatal surgical referrals to other hospitals.

Diagnosis	Number of patients	Hospital
Cyanotic congenital heart disease	3	Great Ormond Street
Tracheo-oesophageal fistula	3	Great Ormond Street
Imperforate anus	1	Queen Elizabeth Hospital, Hackney

Table 6. Emergency use of the paediatric theatre.

Time of day	All	Non-orthopaedic	In paediatric theatre
Daytime (0800 to 2000 hours)	239	175	40 (23%)
Night-time (2000 to 0800 hours)	174	81	12 (15%)

The adult intensive care unit (ICU) admitted 25 paediatric patients (18 children, four toddlers and three infants). Fifteen patients required mechanical ventilation, including the three infants and two of the toddlers. Eight patients required an emergency CT scan; three of these died subsequently. Two of the deaths were as a result of severe head injury and the third from a subarachnoid haemorrhage. A child with viral encephalitis was transferred to a Supraregional hospital for intracranial pressure monitoring; another with a depressed skull fracture was transferred to the Regional neurosurgical centre.

Discussion

We have reviewed the data for all children up to 13 years of age. However, it is those under 3 years of age who cause anaesthetists greatest concern because of their special anaesthetic needs.^{1,2} In this DGH, 558 anaesthetics (19% of all paediatric cases) were administered to children under 3 years of age; 383 (69%) were given by consultants. This represents an average of two cases per consultant per month which is considerably less than the 1–2 cases per consultant per week calculated by Hatch.¹ The skills of all the consultant staff cannot be maintained with this number. The

Table 7. The number of anaesthetics given to children under 3 years of age by 16 consultants, related to the time they spent as anaesthetic trainees in recognised paediatric centres.

Number of anaesthetics	Number of months in training				Total
	0	< 6	6-11	12-17	
Greater than 50	1	1	1	0	3
20 to 50	0	0	1	2	3
5 to 19	1	1	2	2	6
Less than 5	1	2	1	0	4
Total	3	4	5	4	16

number of cases is certainly insufficient to provide the training necessary for junior staff to be able to give anaesthetics unsupervised to this age group. Ideally, all these children should be anaesthetised by one of a small group of consultants (those who had the most extensive training in paediatric anaesthesia) thus giving them the greatest opportunity to maintain their skills.² This was a recommendation to the Court committee.³ However, a consultant post advertised as containing some paediatric work may result in the appointment of an anaesthetist with little fulltime training in paediatric anaesthesia. Conversely, a consultant appointed to a post with a major interest outside the paediatric field may coincidentally have had extensive training in paediatric anaesthesia. An example of this incongruity can be seen in Table 7; one consultant with no formal training in a paediatric hospital anaesthetised more than 50 patients under 3 years old, but another with 17 months of such training performed less than 20 anaesthetics in this age group. Steps are being taken to try to correct this anomaly in our department.

Perhaps the most contentious issue with regard to specialist paediatric anaesthetists in a DGH is the provision of emergency cover. In 1987, only 25 patients less than 3 years of age, including three neonates, required anaesthetics after 2000 hours (approximately two per month). It is difficult to justify a paediatric anaesthetist on-call rota because of this small number, particularly as other subspecialists, for example thoracic anaesthetists, could make similar demands. The Court report³ recommended more centralisation of

paediatric surgery into Regional or Supraregional centres. East Anglia lacks a Regional paediatric surgical unit and all referrals are to a Supraregional centre approximately 120 miles away in central London. This centre would have an extra workload of approximately 100 anaesthetics per annum if all neonates and infants and toddlers who require major surgery were transferred. However, these procedures help to maintain consultant skills for the emergencies which cannot be transferred.⁴

The neonatal intensive care unit is funded regionally and neonates are transferred to this unit from other districts. The pre- and postoperative care of neonatal patients is performed by the paediatricians; the anaesthetist is involved only in the perioperative management. This is true particularly for a neonate with a PDA; both the anaesthetist and the surgeon are in effect performing a technical procedure for the neonatologists. It is difficult for anaesthetists in a DGH to suggest that neonates be transferred to other centres because they feel unable to cope with this function.

Three points emerge. Firstly, there are barely sufficient cases under the age of 3 years for consultants to maintain their skills with this age group and certainly not enough for adequate training of junior staff. Secondly, a consultant's previous paediatric anaesthetic training may be wasted unless care is taken to match this to his or her current work. Finally, we found no data to support the policy of transfer, for anaesthetic reasons, of all neonates to a Supraregional centre from this DGH.

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Anaesthesia for patients over 90 years of age.

Outcomes after regional and general anaesthetic techniques for two common surgical procedures

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Summary

Peri-operative morbidity and mortality and long term outcome of patients over 90 years of age who underwent either total hip arthroplasty or transurethral prostate resection were studied retrospectively. The outcomes of patients who received regional or general anaesthesia were compared. One hundred and forty-one patients underwent total hip arthroplasty and 44 patients underwent transurethral prostate resection during the study period (1975-1985). Overall in-hospital mortality was 4.9%. Mortality at 30 days was 5.3% in patients who underwent hip arthroplasty during regional anaesthesia, compared with 6.8% in those who received general anaesthesia. Long term survival was similar for these two groups and was longer than projected for age and

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gender-matched general population cohorts. The 30-day mortality rate was 3.2% for patients who underwent prostatic resection under regional anaesthesia; no deaths occurred in the general anaesthesia group. This difference was not statistically significant. Long term survival was similar for patients in both groups and was better than predicted. Anaesthetic technique did not influence short term morbidity and mortality or long term outcome for these procedures.

Key words

Anaesthetic techniques; regional, general. Complications; death.

Surgical procedures in the elderly are associated with higher peri-operative morbidity and mortality than in younger patients.^{1,2} This is especially significant because elderly individuals are more likely to be operated on now than in the past³ and because they represent the fastest growing subset of the population in the United States.⁴ The number of very old patients has been increasing at a remarkable rate for the past 40 years,⁵ and their absolute numbers are now sufficiently large to exert a major impact on the health care system. Anaesthetists are increasingly confronted with the challenges of providing anaesthesia for these patients.

Age-related changes affect almost all organ systems and may compromise the ability of elderly patients to tolerate peri-operative stresses. The relative merits of regional and general anaesthesia in this setting have been studied with conflicting results.⁶⁻¹² Therefore, we compared retrospectively the outcome of patients who received regional or general anaesthesia for either total hip arthroplasty (THA) or transurethral resection of the prostate (TURP), two of the most frequently performed operations in the elderly.^{2,13} We reviewed the peri-operative morbidity and mortality and long term survival of patients who were 90 years of age or older, and who underwent THA or TURP at our institution over the 11-year period, 1975 to 1985.

Methods

Study subjects. During the 11-year period, 1975-85, 1063 operations were performed at the Mayo Clinic on patients who were 90 years of age or more at the time of their surgery. The study series includes 141 patients who underwent THA and 44 patients who underwent TURP.

Each patient was classified pre-operatively according to the physical status classification (ASA class) of the American Society of Anesthesiologists, and pre-operative medical conditions were determined by individual chart review. At our institution, all patients must undergo a pre-anaesthetic examination by an internist before a surgical procedure and, when capable, complete a questionnaire that details their medical history. The Mayo employs a unit medical record system, and the complete history of every patient, including outpatient as well as inpatient data, is available for review. Anaesthetic technique was defined as either regional (epidural or spinal) or general anaesthesia.

Pre-operative conditions. Hypertension, angina, chronic obstructive pulmonary disease, endocrine disease, and arrhythmia were defined as present if the patient was receiving medical therapy for the condition at the time of surgery. Previous myocardial infarction was identified by the presence of Q waves at least 0.04 seconds in duration and 1 mm deep on the electrocardiogram (ECG). Prior coronary artery bypass or cardiac valvular surgery were recorded. Smoking history was recorded from the patient questionnaire and defined as never smoked, prior smoker (stopped > 2 months), current smoker, or smoker but past or current status unknown. A pre-operative serum creatinine concentration > 175 $\mu\text{mol/litre}$ or the use of dialysis defined renal dysfunction. Prior history of malignancy, surgery, radiation therapy, or chemotherapy for malignancy was recorded. Biliary disease was defined as present if the total bilirubin concentration was > 50 $\mu\text{mol/litre}$,

alkaline phosphatase > 375 iu/litre or aspartate serum transferase (AST) > 45 iu/litre. Central nervous system disease was identified in patients with medically documented cerebral vascular accident, transient ischaemic attack, or neurological deficit of central origin.

Morbidity. Only major peri-operative morbidity was considered. Myocardial infarction was defined as the new appearance of Q waves at least 0.04 seconds wide and 1 mm deep on ECG or an elevation of creatine phosphokinase MB isoenzyme consistent with myocardial infarction. Pulmonary embolus was defined by appropriate defects on pulmonary angiography or a ventilation-perfusion scan consistent with a high probability of pulmonary embolus. Central nervous system morbidity was defined as a new cerebral vascular accident, transient ischaemic attack, or neurological deficit of central origin. Renal dysfunction was defined as a serum creatinine concentration > 175 $\mu\text{mol/litre}$ or the need for dialysis in a patient with normal renal function before surgery. Biliary dysfunction was defined as a serum total bilirubin concentration > 50 $\mu\text{mol/litre}$, alkaline phosphatase > 375 iu/litre or AST > 45 iu/litre in a patient with normal liver function tests before surgery. Mechanical ventilation for more than 24 hours postoperatively, or the need to intubate the trachea and ventilate the lungs mechanically in a patient previously extubated was classed as respiratory failure. Postoperative morbidity was divided into three periods: intra-operative; < 48 hours postoperatively; and \geq 48 hours but \leq 30 days postoperatively.

Mortality. All patients were followed to the time of death or termination of study. Survival curves were estimated using Kaplan-Meier methodology.¹⁴ Expected survival curves for deaths from all causes were computed for persons of like age, gender, and calendar year of birth, based on cohort life tables constructed for the West North Central region of the United States.¹⁵ The 30-day mortality rate was calculated using Kaplan-Meier methodology. Hospital mortality was determined as any death during hospitalisation for the procedure.

Analysis. Group comparisons of observed survival were performed by log-rank test. Chi-squared and Fisher's exact tests were used to evaluate associations between type of anaesthesia and presence of various patient characteristics. A p value \leq 0.05 was considered statistically significant.

Results

There was a high prevalence of chronic disease (Table 1), but 95.1% of the 185 patients were discharged from the hospital alive after surgery. One hundred and forty-nine patients were aged 90-94 years, 33 patients were aged 95-99 years, and three patients were aged 100 years or older at the time of surgery. There were 74 males and 111 females.

Total hip arthroplasty. One hundred and forty-one patients underwent THA. Fractures of the femur were present in 123 (87.2%) patients. The regional anaesthesia group consisted of 38 patients (28 spinals and 10 epidurals) and the general anaesthesia group, 103 patients. The prevalence of pre-operative chronic diseases was similar for the two groups (Table 1).

Table 1. Characteristics of patients aged 90 years or more who underwent total hip arthroplasty (THA) or transurethral resection of the prostate (TURP) at Mayo Clinic, 1975–1985.

Patient characteristics	THA					TURP				
	General		Regional		p	General		Regional		p
	n	%	n	%		n	%	n	%	
Sex: M	20	19.4	10	26.3	NS	13	100.0	31	100.0	—
F	83	80.6	28	73.7		—	—	—	—	
Age group: 90–94	81	78.6	27	71.1	NS	11	84.6	30	96.8	NS
95–99	21	20.4	9	23.7		2	15.4	1	3.2	
100+	1	1.0	2	5.3		0	0.0	0	0.0	
Known hypertension	45	43.7	14	36.8	NS	4	30.8	9	29.0	NS
Arrhythmia	19	18.4	4	10.5	NS	1	7.7	8	25.8	NS
Previous CNS disease	31	30.7	11	29.7	NS	2	15.4	6	20.0	NS
Prior myocardial infarction	18	17.5	8	21.1	NS	3	23.1	5	16.1	NS
Previous cancer	15	15.2	10	26.3	NS	2	16.7	14	45.2	NS
Known angina	13	12.6	5	13.2	NS	1	7.7	6	19.4	NS
Previous endocrine disease	8	7.8	2	5.3	NS	0	0.0	3	9.7	NS
Previous biliary disease	1	1.3	1	3.4	NS	0	0.0	0	0.0	NS
Previous renal disease	5	4.8	0	0.0	NS	2	15.4	3	9.7	NS
Known COPD	2	1.9	2	5.3	NS	0	0.0	1	3.2	NS
Cigarette smoking status:										
Never smoked	49	47.6	23	60.5	NS	4	30.8	10	32.3	NS
Past (stopped > 2 months ago)	9	8.7	2	5.3		3	23.1	10	32.3	
Current smoker	2	1.9	2	5.3		1	7.7	4	12.9	
Smoker/unknown past or current	3	2.9	0	0.0		0	0.0	2	6.5	
Unknown	40	38.8	11	28.9		5	38.5	5	16.1	
ASA status: 1	0	0.0	0	0.0	NS	0	0.0	0	0.0	NS
2	11	10.7	1	2.6		3	23.1	8	25.8	
3	70	68.0	25	65.8		8	61.5	19	61.3	
4	21	20.4	12	31.6		2	15.4	4	12.9	
5	1	1.0	0	0.0		0	0.0	0	0.0	

NS, not significant.

Table 2. Morbidity and mortality among patients aged 90 years or more who underwent total hip arthroplasty (THA) or transurethral resection of the prostate (TURP) at Mayo Clinic, 1975–85.

Group	n	Morbidity							7. Death in < 48 hours	Any of 1-7	Mortality		
		1. MI	2. PE	3. CNS	4. Renal	5. Biliary	6. MV > 24 hours	Any of 1-6			30 days	1 year	5 years
THA													
General	103	1.0%	1.9%	2.9%	1.9%	2.9%	1.9%	11.6%	1.0%	11.6%	6.8%	28.6%	72.0%
Regional	38	2.6	2.6	5.3	2.6	5.3	0.0	15.8	2.6	18.4	5.3	20.0	61.2
TURP													
General	13	0.0	0.0	0.0	15.4	0.0	0.0	15.4	0.0	15.4	0.0	27.3	—
Regional	31	0.0	0.0	3.2	6.5	0.0	0.0	9.7	0.0	9.7	3.2	33.8	90.6

MI, myocardial infarction; PE, pulmonary embolism; CNS, central nervous system; MV, mechanical ventilation. Morbidity categories are not mutually exclusive.

There are no statistically significant differences between general and regional groups in any category.

Major morbidity occurred with a frequency of 15.8% in the regional group and 11.6% in the general group (Table 2). The most common postoperative conditions in both anaesthetic groups were transient ischaemic attacks and acute reversible biliary dysfunction. There was a 5.7% total in-hospital mortality (5.3% in the regional group and 5.8% in the general group). One intra-operative death occurred in each anaesthetic group after the femoral component had been cemented. Other deaths before discharge in patients who underwent general anaesthesia were caused by pneumonia and sepsis (4) and congestive heart failure (1). One patient who underwent regional anaesthesia died in hospital from pneumonia and sepsis. An additional patient who underwent general anaesthesia died from a myocardial infarction after hospital discharge but within 30 days of surgery. Thus, for the general group, in-hospital mortality was 5.8% but 30-day mortality was 6.8%. Long term

follow-up revealed comparable 1-year and 5-year mortality rates between groups (Table 2). Survival in both groups was greater than projected for age and gender-matched controls (Figs 1 and 2).

Transurethral prostate resection. Forty-four patients underwent TURP. The prevalence of chronic disease pre-operatively was not statistically different between the two groups (Table 1). In general, however, patients who were being treated for arrhythmias or angina were more likely to have a regional anaesthetic. Major morbidity occurred with a similar frequency in each anaesthesia group (31 spinals, 13 generals), and was similar to that seen in the THA cohort (Table 2). No deaths occurred in the operative or early postoperative (< 48 hours) periods. There was one death from myocardial infarction within 30 days of surgery in the regional group and none in the general group (Table 2). Mortality rates at 1 and 5 years were comparable be-

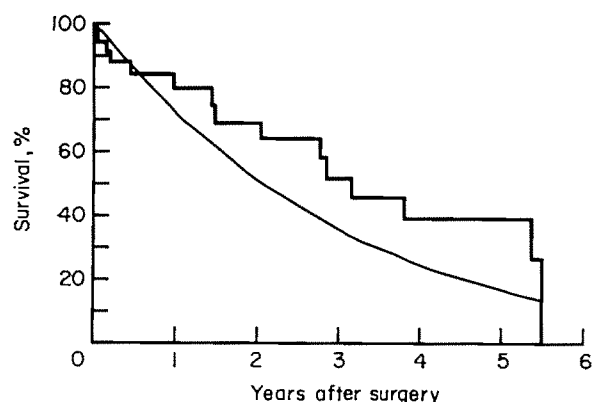


Fig. 1. Survival of patients aged 90 years or more who underwent total hip arthroplasty with regional anaesthesia (—) compared to that of age and gender-matched controls (---). Differences are not statistically significant.

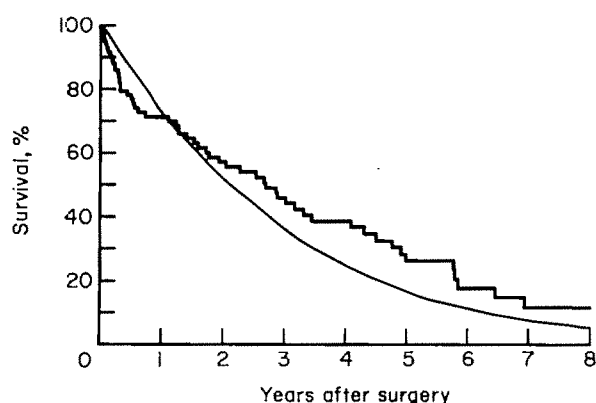


Fig. 2. Survival of patients aged 90 years or more who underwent total hip arthroplasty with general anaesthesia (—) compared to that of age and gender-matched controls (---). Differences are not statistically significant.

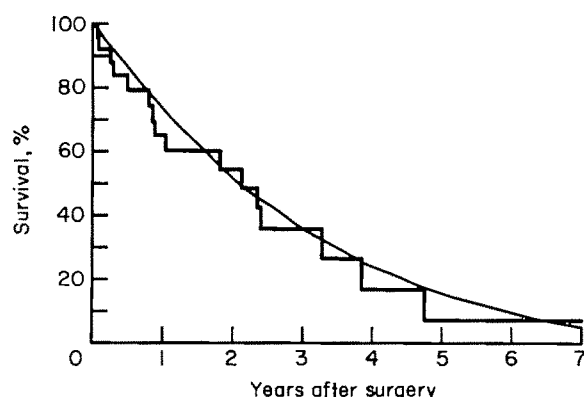


Fig. 3. Survival of patients aged 90 years or more who underwent transurethral resection of the prostate with regional anaesthesia (—) compared to that of age and gender-matched controls (---). Differences are not statistically significant.

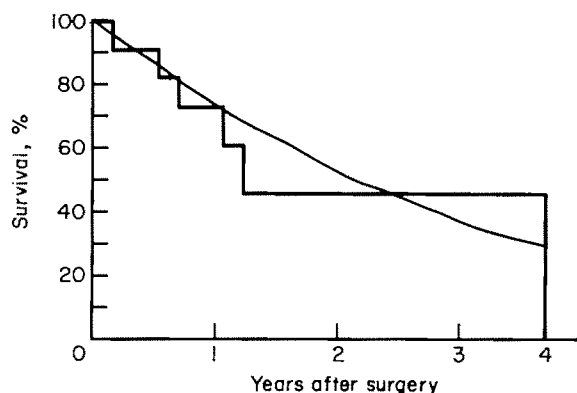


Fig. 4. Survival of patients aged 90 years or more who underwent transurethral resection of the prostate with general anaesthesia (—) compared to that of age and gender-matched controls (---). Differences are not statistically significant.

tween groups. Survival in both groups was better than predicted for individuals of like age and sex from the general population (Figs 3 and 4).

Discussion

The population of the United States is growing older. Between 1960 and 1980, the number of persons aged 65 years and over increased at a rate double that of the general population (54 as compared with 26%).⁵ During this same period, the oldest group of the population (> 85 years) increased by 141%. More of these very old patients will be considered for surgical procedures as the population ages. Indications will be influenced, in turn, by the outcome of surgery. The present study shows that patients aged 90 years or older tolerate THA and TURP relatively well. Overall, 30-day mortality was 5.4%, with rates for THA and TURP of 6.4% and 2.6%, respectively. These figures contrast with the results of Denney and Denson¹⁶ two decades ago, who reported 30-day mortality rates in patients similar to ours of 25% for THA and 21% for TURP. The enhanced survival may be a result of surgical and anaesthetic advances and improved medical care. However, noncomparability of the patient populations in the two studies might also account for some of the differences in outcome.

The physiological changes that occur with ageing may leave these patients with a markedly diminished capacity to respond to the stresses of surgery and anaesthesia.¹⁷ The notion that regional anaesthesia is inherently safer for the elderly has often been stated, frequently with little supportive data. Nonetheless, the ability of regional anaesthesia to blunt, at least in part, the stress response to surgery is now well documented.¹⁸⁻²⁰ In addition, the use of regional anaesthesia may modify the haemostatic response to surgery and decrease the incidence of postoperative deep venous thrombosis.^{21,22} Proponents of regional anaesthesia cite these data as evidence of the superiority of regional over general anaesthesia. Data on peri-operative outcome, however, have been equivocal.^{6-12,23}

The elderly are generally considered to be persons > 65 years of age. However, a wide discrepancy between chronological and biological age may exist in such a diverse group,²⁴ and general conclusions drawn from studies of such a group may be erroneous. Thus, we compared regional and general anaesthesia in patients aged 90 years or over because few would disagree that these patients are, indeed, old. We also studied patient survival because of a lack of long term outcome studies in the anaesthetic literature.²⁵ The survival period studied was much longer than the usual one week or 30 postoperative days in most studies. This prolongation allowed identification of late morbidity such

as pulmonary thromboembolism. We were unable to find any statistical association between anaesthetic technique and the occurrence of postoperative pulmonary embolus.

This study was retrospective and each anaesthetist chose the technique that he or she felt was best for the patient. Patients who underwent regional or general anaesthesia for each procedure were comparable in respect of the prevalence of pre-existing disease. However, patients who were being treated for angina or arrhythmias were more often anaesthetised with a regional technique for TURP. A current study of predictive pre-operative factors and risk of peri-operative morbidity and mortality in patients aged 90 years or more who undergo any surgical procedure at our institution has revealed that patients who receive treatment for an atrial arrhythmia, but not angina, have an increased peri-operative mortality risk. This risk is twice that of patients without atrial arrhythmias for the first 48 hours, and 50% greater within one year. A 50% increase in postoperative mortality at one year in our patients who underwent TURP with general anaesthesia would not create a statistically significant difference between regional and general anaesthetic groups.

There were no morbidity or mortality differences between patients who received spinal or epidural anaesthesia for THA. McLaren *et al.*⁶ reported a 25% 2-week mortality rate in elderly patients who underwent hip surgery during general anaesthesia compared to no mortality in similar patients who received spinal anaesthesia. In that report, all but two deaths were respiratory in origin. However, the spinal anaesthesia group received a light general anaesthetic with the same agents as in the general anaesthesia group (Althesin and Entonox); thus, the aetiology of this wide disparity in mortality is unclear. Hole *et al.*⁷ conducted a randomised study of 60 patients who underwent THA, and found a higher incidence of postoperative mental confusion and hypoxaemia in those who received general anaesthesia compared with a similar epidural anaesthesia group. No significant differences in mortality occurred. McKenzie *et al.*⁸ obtained similar results in 100 patients who received either general or spinal anaesthesia for hip surgery. Mortality was not significantly different, but postoperative arterial oxygen tension was lower in the general anaesthesia group. Davis and Laurenson⁹ reported lower incidences of deep venous thrombosis, postoperative hypoxaemia and reduced blood loss in patients who received spinal anaesthesia compared with general anaesthesia for THA, but they found no significant difference in mortality. Berggren *et al.*¹¹ reported no significant difference between the incidences of postoperative confusion in elderly patients randomised to receive either general or epidural anaesthesia for femoral neck fracture. Indeed, anticholinergic medications and a history of mental depression were the predominant risk factors for postoperative confusion. A review of 200 patients who received spinal or general anaesthesia for TURP showed no significant differences in morbidity, mortality, or length of hospital stay.¹²

Differences in long term survival were studied by Wickstrom *et al.*¹⁰ in 169 elderly females randomised to receive epidural, neuroleptic, ketamine, enflurane, or halothane anaesthesia for hip fracture surgery. Overall 30-day mortality was 6.5% and there were no differences among anaesthetic techniques. Patient age and type of fracture were found to correlate with mortality. These authors examined long term survival at 1 and 4 years. No consistent differences in survival were found between the anaesthetic methods when corrected for age and fracture type. They also found that observed survival, when compared to expected survival in age and gender-matched control groups from the same population, was decreased for all anaesthetic techniques. This decreased survival

contrasts with our study which demonstrated no reduction in survival compared with cohorts from the population. The advanced age and consequently lower projected survival rate in our patients may account for this discrepancy in results.

In summary, we found no significant differences in peri-operative major morbidity and mortality or long term outcome between patients aged 90 years or more who received regional or general anaesthesia for THA or TURP. Long term survival was equivalent to, or greater than, that projected for each group on the basis of age and gender-matched data from the general population. Overall 30-day mortality was significantly lower than comparable figures in similar patients reported two decades earlier.¹⁶

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Postdural puncture headache

A comparison between 26- and 29-gauge needles in young patients

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Summary

The incidence of postdural puncture headache after spinal anaesthesia with two types of 26- and 29-gauge needles was investigated in 149 patients less than 30 years old. Ten patients, (6.7%), six men and four women, developed typical symptoms of postdural puncture headache, while six (4.0%) developed headache of other origin. There were no headaches in the 29-gauge group. Spinal anaesthesia in four patients (8%) was impossible to perform with the 29-gauge needle. By using the latter, spinal anaesthesia can be given to young adults with little risk of postdural puncture headache.

Key words

Anaesthesia techniques; regional, spinal.
Complications; headache.

A high incidence of postdural headache is reported in young adults who receive spinal anaesthesia,^{1–3} and because of this complication many anaesthetists avoid sub-arachnoid block in these patients.^{3,4} We reported recently a high incidence of headache in young patients who received spinal anaesthesia using 25-gauge needles.³ Use of 29-gauge needles is associated with a reduced incidence of headache even in young patients.⁵

The present study compared the frequency of postdural puncture headache in young patients using either 26- or 29-gauge needles.

Methods

The study was carried out at one large university hospital (1200 beds) and one smaller community hospital (250 beds), both on the western coast of Norway. One hundred and fifty-one ASA group 1 patients less than 30 years of age scheduled for minor surgery, were allocated randomly to have spinal anaesthesia with a 29-gauge needle (Becton and Dickinson, BD), or one of two 26-gauge needles (BD and Braun). All patients gave their consent.

Lumbar puncture was performed in the L_{2/3} or L_{3/4} interspace with the patients in the lateral position. A 20-gauge spinal needle introducer was used with the 29-gauge needle, but only according to preference of the anaesthetist when using a 26-gauge needle. The skin and subcutaneous tissues were infiltrated with lignocaine 1% when an introducer was used. The introducer was then advanced into the

interspinous ligament to facilitate introduction of the thinner spinal needle. The bevel of the spinal needle was kept parallel to the dural fibres. Spinal anaesthesia was performed with isobaric bupivacaine 0.5%, or hyperbaric lignocaine 5%. Correct positioning of the 26-gauge needles was confirmed by appearance of cerebrospinal fluid (CSF) in the plastic hub. This was not possible when the 29-gauge needle was used and CSF was identified in one of two ways: either with a horizontal light into the hub to detect a tiny meniscus of CSF after the stylette was removed, or careful aspiration with a 1-ml syringe attached to the needle.

Postoperatively patients were free to mobilise as soon as full power had returned to the legs. All patients remained at least one night in the hospital before they were discharged. On the third postoperative day all patients were interviewed in a standardised way by one of the investigators with special regard to the occurrence of postoperative headache. The headache was classified as postdural puncture or 'ordinary' headache as previously described.³ Patients suffering from severe postdural puncture headache were offered an epidural blood patch. The Chi-squared test with Yates' correction was used to evaluate statistical significance, using p values <0.05 as significant.

Results

The results from 149 patients, 104 men and 45 women, mean age of 21.8 years, were evaluated. Results of two

Table 1. Groups of patients studied.

Size and type of needle	Number	Mean age, years (SD)	Male:female	Successful puncture (%)
26 Braun	48	22.2 (5.2)	33:15	100
26 BD	51	21.5 (4.8)	32:19	100
29 BD	50	21.8 (4.1)	39:11	92*

* The four patients were successfully punctured using a 26-gauge needle.

Table 2. Postoperative headache.

		Postdural puncture		Other headache
	Number of patients	headache		
26 Braun	48	7	} 10*	2
26 BD	51	3		4
29 BD	50	0*		0

* $p < 0.05$.

Table 3. Data on patients with postdural puncture headache.

	Age*	Sex	Spinal needle	Days of headache†	Blood patch
Patient 1	18	Female	26 BD	5	No
Patient 2	26	Male	26 BD	3	No
Patient 3	25	Male	26 BD	4	Yes
Patient 4	20	Female	26 Braun	2	No
Patient 5	20	Female	26 Braun	2	Yes
Patient 6	29	Female	26 Braun	4	Yes
Patient 7	18	Male	26 Braun	2	No
Patient 8	24	Male	26 Braun	3	No
Patient 9	19	Male	26 Braun	7	No
Patient 10	26	Male	26 Braun	3	Yes

* Mean, 22.5 years; † mean, 3.5 days.

patients were excluded because of accidental dural puncture with the introducer needle. Data about the three groups of patients are given in Table 1. Most patients (79%) underwent orthopaedic procedures of the lower limb. Postoperative headache occurred in 16 patients and of these, 10 (6.7%) were classified as of the postdural puncture type. The headache was severe in four who also complained of additional symptoms such as tinnitus, vertigo and vomiting. No patient developed postdural puncture headache after the use of a 29-gauge needle. There were no differences between the two 26-gauge needles with regard to technical problems or incidence of headache. Classification of headaches within each of the groups are given in Table 2. Additional information about the patients with postdural puncture headache are given in Table 3.

Discussion

In this study, postdural puncture headache did not occur after use of 29-gauge needles, compared to 10.1% when a 26-gauge needle was used. However, dural puncture with the 29-gauge needle was more difficult and there were four failures.

Dural puncture in young adults, both as a diagnostic procedure and in connexion with spinal anaesthesia, has a high frequency of headache.^{1,2,6,7} Several prophylactic methods intended to reduce the frequency of headache have been investigated. Use of prolonged bed rest,⁸⁻¹⁰ the prone as compared with the supine position,¹¹ extra hydration,¹² prophylactic blood patch¹² or indomethacin³ have all failed to reduce the incidence of postdural puncture headache. The shape of the needle and the direction of the bevel

relative to the dural fibres have been shown to influence incidence of headache,¹³ but valid data when needles less than 26-gauge are used are missing. The only effective way to reduce postdural puncture headache is by using small bore needles^{5,14,15} and to avoid dural puncture in young adults, especially females.¹⁻³

There are few controlled studies that compare spinal needles in young patients only. Tourtelotte *et al.*¹⁵ found, in their double-blind study in young volunteers, a reduction of headache from 36% to 12% when a 26- instead of a 22-gauge needle was used. Extraction of data from studies of spinal anaesthesia in a wide range of ages indicates that small-sized needles reduce the incidence of headache in young adults.² An important exception is in children, where dural puncture is usually associated with an uneventful recovery.¹⁶

Postdural puncture headache is more frequent in women, especially in the 20 to 40 years age group.^{1,2,17} We have reported previously an incidence of 61.5% in women less than 30 years old when given spinal anaesthesia with a 25-gauge needle, compared to 23.4% in men of the same age.³ In the present study, using 26-gauge needles, the incidence of headache in men and women was nearly identical: 9.2% as compared with 11.8%, respectively; none occurred with the 29-gauge needle.

Fine needles reduce the incidence of postdural puncture headache but the mandatory use of a separate introducer needle carries the risk of accidental dural puncture with the introducer. We experienced two accidental dural punctures in our study and one of these developed a spinal headache. It is possible that a technique that involved identification of the epidural space in the first instance before use of a spinal needle, could avoid this problem. This will, however, make the procedure more complicated and identification of the epidural space is not free from the hazard of accidental dural puncture.¹⁸ However, on occasion, it may not be possible to verify the correct position of very fine needles. This occurred in four of our patients when CSF could not be identified and a 26-gauge needle had to be used through the same introducer. This will increase the possibility of postdural puncture headache.

Conclusion

The possibility of the development of postdural puncture headache should not stop anaesthetists from using spinal anaesthesia, even in young adults. Use of 29-gauge needles will virtually eliminate the complication, but they are technically more difficult to use. A 10% incidence of headache is to be expected if a 26-gauge needle is used in this group of patients.

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Intra-operative collapse or death related to the use of acrylic cement in hip surgery

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Summary

Six intra-operative deaths and two episodes of near-fatal hypotension occurred in 52 consecutive Hastings procedures (insertion of metal prosthesis grouted in acrylic cement) for subcapital fracture of the femoral neck. This high complication rate was identified by a system of clinical audit undertaken by members of the anaesthetic department.

Key words

Surgery; orthopaedic, hip prosthesis, methylmethacrylate cement.
Complications; hypotension, death.

The Confidential Enquiry into Perioperative Deaths (CEPOD)¹ recommended local clinical audit as a means of maintenance of, and improvement in, standards of anaesthetic practice. We have undertaken a retrospective study of peri-operative mortality in patients who underwent hip surgery in a small District General Hospital, and identified factors which may have contributed to the mortality associated with one type of operative procedure.

Patients and methods

The operating theatre logbook was used to obtain the names and record numbers of all patients who underwent hip surgery between January 1984 and June 1986. One hundred and forty-five patients underwent elective arthroplasty of the hip during this period, and 154 underwent surgical fixation of a fractured femoral neck. Fifty of the patients who required non-elective surgery were treated by the Hastings procedure, in which a metal prosthesis, grouted in acrylic cement, is inserted; the indication for this procedure was the presence of an intracapsular fracture as demonstrated radiologically. Two patients underwent semi-elective revision of a Hastings procedure. Table 1 lists the age and gender distribution of patients in the three groups. The patients were referred from the industrial community of West Fife and belonged mostly to social classes 3–5.

Results

All anaesthetics were administered by a consultant; there are no junior anaesthetists in our department. Twenty-eight percent of operations were carried out under spinal or extradural anaesthesia, and the remainder of the patients received general anaesthesia (Table 2). The electrocardiogram (ECG) and arterial pressure were monitored in every patient. Attempts were made to ensure that patients were adequately prepared and hydrated before surgery, but some who were clearly unfit (ASA grade 4) were accepted because surgery was felt to be their only chance of survival.

Eight patients suffered intra-operative collapse (Table 3); seven patients developed severe hypotension and bradycardia, but asystole was the presenting feature in one. Six patients collapsed during an emergency Hastings procedure; four died during operation and one died on the fifth post-operative day. The other two patients who collapsed died during elective revision of a Hastings procedure. No patient died during fixation of a hip fracture which did not require acrylic cement, although 16 patients died within 12 weeks of operation (Table 4).

Coexisting medical conditions were present in several of the patients who collapsed, and three of the patients were classified as ASA grade 4. Most patients with fractured neck of femur were operated on within a few hours of admission, usually at night or at weekends; operation was

Table 1. Details of patients who underwent hip surgery.

		Age group (years)					Totals
		50-59	60-69	70-79	80-89	90-99	
Hastings operation	Male		3	6	3	12	52
	Female	3	6	12	18	1	
Other methods of internal fixation	Male	1	3	5	8	1	102
	Female	6	12	23	35	8	
Elective arthroplasty	Male		15	53	1	69	145
	Female	1	15	59	1	76	

Table 2. Age groups of patients who underwent emergency hip surgery during epidural/spinal nerve block or general anaesthesia.

		Age group				
		50-59	60-69	70-79	80-89	90-99
Hastings operation	Epidural/spinal	1	2	8	4	1
	General anaesthesia	2	7	10	15	0
Other methods of internal fixation	Epidural/spinal	2	3	7	12	4
	General anaesthesia	5	12	21	31	5

Table 3. A summary of eight cases, giving cause of collapse and status of operators.

Case No.	Age	Sex	Hb	ASA	Ward blood pressure	H + B or CA	Status of surgeon	Status of anaesthetist	Anaesthetic	Status of operation
1	76	M	12.8	3	120/80	H + B	Registrar	Consultant	Spinal	Emergency
2	82	F	12.2	3	130/70	H + B	Registrar	Consultant	GA (IPPV)	Emergency
3	79	F	10.8	4	130/90	H + B	Registrar	Consultant	GA (IPPV)	Emergency
4	83	F	10.3	4	120/60	H + B	Registrar	Consultant	Spinal	Emergency
5	86	F	12.8	3	150/90	CA	Consultant	Consultant	GA	Elective
6	84	F	12.0	4	110/70	H + B	Consultant	Consultant	Epidural	Elective
7	70	F	13.0	2/3	120/75	H + B	Registrar	Consultant	Spinal	Emergency
8	84	F	11.8	3	130/85	H + B	Registrar	Consultant	GA (IPPV)	Emergency

H + B, hypotension with bradycardia; CA, cardiac arrest; GA, general anaesthesia.

Table 4. Survival after hip surgery.

	Intra-operative		Survived under (number of days indicated)					Survived over 84 days
	collapses	deaths	7	14	28	56	84	
Hastings operation								
Emergency	6	4	1	0	0	0	0	45
Elective	2	2	0	0	0	0	0	0
Other methods of internal fixation	0	0	2	4	2	5	3	76*
Elective arthroplasty	0	0	0	0	0	0	0	145

* 10 patients lost to follow-up, presumably dead.

delayed by up to 48 hours if necessary to improve the patient's general condition. Resuscitation was undertaken by the orthopaedic surgeons, who followed an established protocol.

All of the patients who collapsed during an emergency Hastings procedure were operated on by a registrar surgeon; a consultant surgeon performed the elective procedures (Table 3). In all cases, the acrylic cement was kneaded to eliminate unfixed monomer and the medullary cavity was emptied before insertion of cement; in most cases, holes were drilled in the femoral shaft to relieve any increase in intramedullary pressure during insertion of the prosthesis.

Four of the patients who collapsed had received a general anaesthetic, and four underwent regional anaesthesia. The youngest of these patients was aged 70 years, and the oldest 86 years. Postmortem was not performed on any of the

patients who died; our hospital no longer has facilities for this procedure.

Brief case histories of the patients who collapsed are detailed below.

Case 1. A 76-year-old chronic bronchitic man suffered a transcervical fracture after falling from a bus. He was resuscitated with intravenous fluids for 8 hours before being considered fit for surgery. A spinal anaesthetic was performed using 2.7 ml of bupivacaine 0.5%, and he received etomidate 10 mg and midazolam 7 mg intravenously. A profound bradycardia developed 15 minutes after the insertion of acrylic cement into the femoral shaft, and his systolic arterial pressure, which had been 110 mmHg, decreased to an unrecordable level. His trachea was intubated and artificial ventilation started. Cardiac arrest was diagnosed and resuscitation attempted unsuccessfully.

Case 2. An 82-year-old woman known to be suffering from Parkinson's disease and senile dementia, fell down stairs in her home, and was not discovered for 16 hours. She responded well to resuscitation with intravenous fluids (one litre of compound sodium lactate and 500 ml of glucose 5%). She was considered to be fit for surgery 8 hours after admission. General anaesthesia was induced with thiopentone 150 mg. Her trachea was intubated and anaesthesia maintained with nitrous oxide and oxygen, supplemented by trichloroethylene; her lungs were ventilated mechanically. Her systolic arterial pressure remained at approximately 150 mmHg throughout the procedure until 2–3 minutes after insertion of acrylic cement, when it became unrecordable. The ECG remained unchanged, but no peripheral pulses were palpable. Her neck veins became prominent when she was positioned head-down after infusion of one litre of gelatin solution, but there was still no measurable arterial pressure. She developed an isoprenaline-resistant bradycardia despite administration of oxygen 100% and cardiac compression, and subsequently died.

Case 3. A 79-year-old woman sustained a hip fracture after a fall in a geriatric ward where she had been treated for chronic bronchitis and congestive cardiac failure. She was graded as ASA 4. A diuresis was established by administration of frusemide 40 mg, and 500 ml of gelatin solution was administered slowly. Her operation began 8 hours after the fall. Anaesthesia was induced with thiopentone 50 mg, and tracheal intubation facilitated by suxamethonium 50 mg. Anaesthesia was maintained with nitrous oxide 70% in oxygen, supplemented by trichloroethylene, and ventilation was assisted; no further relaxant drugs were administered. Her systolic arterial pressure varied between 120 and 140 mmHg until shortly after insertion of acrylic cement in the medullary cavity, when it became unrecordable. A bradycardia of 50 beats/minute developed, and did not respond to atropine or isoprenaline. Infusion of gelatin and cardiac compression failed to produce any arterial pulsation, despite the continued presence of electrical activity on the ECG. Cyanosis developed despite ventilation with oxygen 100%. Resuscitation attempts were discontinued 10 minutes later.

Case 4. A frail and confused 83-year-old woman underwent a Hastings procedure after preparation for 48 hours. She was graded as ASA 4. Her haemoglobin concentration was 10.3 g/dl, and her serum potassium 3.3 mmol/litre. She received spinal anaesthesia with 2.5 ml bupivacaine 0.5%. The arterial pressure was low initially, but responded to the slow infusion of one litre of glucose/saline; it was recorded as 140/70 mmHg immediately before introduction of the cement, but became unrecordable shortly afterwards. Her breathing became irregular; the ECG showed sinus rhythm. Cyanosis developed, and her trachea was intubated, oxygen administered and cardiac compression started. Asystole developed 5 minutes later, and did not respond to resuscitative attempts.

Case 5. An 86-year-old woman who had undergone a Hastings procedure one month previously presented for revision of the prosthesis. She had been treated for persistent atrial fibrillation, which was controlled with digoxin 62.5 µg daily. Anaesthesia was induced with methohexitone 40 mg, and the trachea intubated after administration of suxamethonium 40 mg. Anaesthesia was maintained with nitrous oxide in oxygen, supplemented by halothane; the patient breathed spontaneously. Blood loss was heavy, and 2 units of red cell concentrate and 500 ml of compound sodium lactate were infused. Asystole developed 3 minutes after insertion of acrylic cement. A cardiac output was restored after application of cardiac massage, but the arterial pressure and heart rate decreased during the next 2 hours despite a dopamine infusion, and the patient died.

Case 6. An 84-year-old woman, graded as ASA 4, required revision of a Hastings prosthesis 4 days after her original operation. She received extradural anaesthesia, together with sedation and analgesia. She collapsed during skin closure; sinus rhythm remained, but her arterial pressure was unrecordable. A progressive bradycardia ensued despite administration of oxygen, cardiac massage and intracardiac adrenaline, and she died 15 minutes later.

Case 7. A 70-year-old woman received spinal anaesthesia with 1.7 ml of hyperbaric lignocaine 5% 6 hours after sustaining a fractured hip. She suddenly stopped talking to the anaesthetist immediately after insertion of cement into the femoral shaft. A bradycardia developed, her neck veins became prominent, she became cyanosed and no arterial pulses were palpable. Her trachea was intubated, oxygen administered and cardiac compression started. Intravenous adrenaline 1 mg was administered; this induced ventricular fibrillation which was treated successfully with a DC countershock. Cardiac massage was continued for several minutes. She regained consciousness, was observed in the coronary care unit for 48 hours and subsequently made an uneventful recovery.

Case 8. A frail 84-year-old woman required surgical reduction of a subcapital fracture. She was treated overnight with one litre of compound sodium lactate and received heparin 5000 units 5 hours before surgery. A further 3000 units were administered at induction of anaesthesia, which was achieved with thiopentone 100 mg. The trachea was intubated after administration of suxamethonium 75 mg, and anaesthesia maintained with nitrous oxide 70% in oxygen supplemented by trichloroethylene. Artificial ventilation of the lungs was employed. There was little haemorrhage, but the systolic arterial pressure decreased by 30 mmHg to 120 mmHg after insertion of cement, and a bradycardia of 40 beats/minute developed. Atropine 0.6 mg increased the heart rate and the arterial pressure, but profound hypotension without bradycardia occurred 20 minutes later. The ECG remained normal, but the neck veins were noted to be prominent. Light, rapid (250/minute) vibration was applied to the chest on the supposition that some form of embolic phenomenon was responsible for her deterioration. Her arterial pressure was restored to 140 mmHg within 20 seconds. However, postoperative surgical haemorrhage resulted in a further episode of hypotension, and she suffered a cerebrovascular accident which resulted in her death 5 days later.

Discussion

Most emergency orthopaedic surgery in this hospital is performed by registrars. This is not an uncommon situation, and was commented upon in the report of the Confidential Enquiry into Perioperative Deaths.^{1,2} However, the deaths were spaced fairly evenly throughout the 30-month study period, and there was no suggestion that the surgical registrars were to blame for the events which occurred in the emergency patients. Two of the deaths took place during elective revision of a Hastings procedure undertaken by consultant surgeons.

The report of the Working Party on Acrylic Cement in Orthopaedic Surgery (WPACOS)³ concluded that hypotension related to the use of acrylic cement was not associated with any particular anaesthetic technique. However, they commented that time might be wasted in performing tracheal intubation if collapse occurred during spinal or epidural anaesthesia. There was no evidence in the present series that the use of regional anaesthesia conferred any benefit in respect of either intra-operative blood loss or mortality.

The use of methylmethacrylate (MMA) cement to grout

Table 5. Possible aetiologies of hypotension associated with the use of methylmethacrylate (MMA) cement. Items 1-6 were suggested by WPACOS.³

1.	A chain of physiological reactions initiated by the absorption of MMA monomer.
2.	Fat embolism; MMA monomer is a fat solvent and may increase the absorption of fat from the marrow of the femur.
3.	Pharmacologically active substances (histamine, kinins, prostaglandins or others) released by, or because of, MMA monomer.
4.	Raised intramedullary pressure.
5.	Hypersensitivity.
6.	A combination of initiating factors (medullary fat, monomer, pharmacologically active substances) that originate at the site of operation.
7.	Air embolism.
8.	Direct cardiovascular effects of MMA cement or monomer.
9.	Peripheral vasodilatation.
10.	Activation within the lungs of the clotting cascade.

a prosthesis during repair of fractured neck of femur has been associated with mortality rates as high as 7-22%,⁴ although the risk is considerably less in elective hip arthroplasty.⁵ The mortality rate in our series of emergency Hastings procedures (10%) is within this range, but is similar to the incidence which led to the establishment of WPACOS in 1970; it is of some concern that no improvement appears to have been achieved. However, the long term results of the procedure are encouraging; 90% of the patients who underwent the emergency Hastings procedure survived for at least 12 weeks, compared with 74.5% of those whose fracture was repaired with hip screws or a pin and plate.

Total hip arthroplasty is a very safe operation; Charnley⁶ claimed to have performed over 10 000 such procedures, with only two intra-operative deaths. None of our patients who underwent elective arthroplasty died.

The aetiology of hypotension associated with the use of acrylic cement is complex. Possible causative factors, including those defined by WPACOS,³ are listed in Table 5.

Air embolism has been incriminated in a number of instances.⁷⁻¹¹ No distinctive murmur was heard in any of these cases. It has been suggested that the heat generated by the cement as it hardens increases the pressure of air trapped in the femoral shaft by 20% and forces it through damaged sinusoids into extra-osseous veins.⁹ The femoral shaft was vented before insertion of cement in most of the patients in our series. The maximum temperature reached by the cement may be as high as 96°C,¹² and it has been claimed that this may cause cardiac arrest by neurogenic stimulation.

Hypersensitivity to MMA monomer has been dismissed as a cause of collapse.¹³ There have been conflicting reports of the direct effect of liquid MMA on the heart;^{14,15} these differences may relate to the different species of animals studied. MMA monomer is a direct myocardial depressant in the isolated perfused rabbit heart.^{15,16} There has been a case report of a patient who developed transient episodes of atrioventricular block on two occasions, 4 weeks apart, immediately after insertion of MMA cement into the femoral cavity.¹⁷ Only one of our patients suffered a primary cardiac arrest; sinus rhythm was maintained in the remainder, although cardiac contractility might have been reduced.

The use of MMA cement during repair of subcapital fracture of the femoral neck has been linked on many occasions with intra-operative hypotension and death from thrombo-embolism or fat embolism,^{4,5,18-20} and unfavourable comparisons made with elective hip arthroplasty, in

which fatalities are rare.^{21,22} The reason for this difference may be related to the fact that the femoral neck is harder and thicker in patients who require elective arthroplasty for osteoarthritis compared with the osteoporotic bone which is common in those who suffer a fractured femoral neck. In addition, the pattern of venous drainage in the two types of bone may be different,³⁰ and this may render the occurrence of pulmonary fat embolism less likely during elective arthroplasty. There may also be some contribution from the response to trauma in patients who have sustained a fracture.

Prophylactic heparin has been shown to be relatively ineffective in preventing complications during and after hip surgery.^{29,31} There is strong activation of the clotting cascade, and the rate of thrombin formation may exceed the rate at which it can be inhibited by heparin.³¹ There is a significant correlation between the release of tissue thromboplastins into the pulmonary circulation and the decreases which occur in arterial oxygen tension and blood pressure during total hip replacement.³² Deposits of intra-vascular fibrin are associated with fat embolism³³ and the pulmonary thrombo-embolism that occurs in adult respiratory distress syndrome (ARDS).³⁴ Pulmonary fat embolism and ARDS may be the same condition,^{34,35} caused by movement of fat not fixed to cells into the lymphatic system and through the thoracic duct into the venous circulation. The lipid class profiles of fat emboli recovered from patients do not match those of marrow lipid or any other readily identifiable source of fat in tissues²⁶ and all patients with a fractured bone show a characteristic elevation in the alpha-lipoprotein fraction of serum.³⁶ These atypical lipids may tend to coalesce in the pulmonary circulation after reaching a critical concentration, or due to activation by traces of MMA cement.¹⁹

The results of this study have led to the use of the uncemented Bateman prosthesis for subcapital fractures. The earlier application of a system of clinical audit, as advocated in the CEPD report,¹ might have made us aware more rapidly of the high risk of mortality during a routine and common surgical procedure.

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Confidential professional reports

A method of assessing the career progress and prospects of anaesthetic senior house officers

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Summary

A proforma is described which is used at 6-monthly intervals to assess the professional progress of anaesthetic senior house officers. The administration of a reporting system as part of the career counselling process is outlined, and its potential for determining the future prospects of junior staff is discussed.

Key words

Manpower; anaesthetists

Education; trainees

Hospital medicine continues to attract more doctors than can be guaranteed long-term careers in their chosen specialty despite ample evidence that promotion-blocks exist at all grades. The 'achieving a balance' package is designed to improve matters but it is salutary to note that the second step on the ladder is destined to become even more competitive as senior house officer (SHO) numbers

increase and registrar vacancies decline. Traditionally these problems were restricted to the so-called popular specialties, such as general medicine and surgery, but it now appears that anaesthesia is treading the same path.

However, hospital medicine will always remain a highly competitive field and inevitably there will be a number of trainees who fail to reach the required standard of expertise,

cannot pass the necessary postgraduate examinations, or for a variety of personal reasons do not stay the course. In the past these doctors were able to transfer to domestic general practice or to emigrate. However, legislation now demands that all principals in general practice must be vocationally trained, and job opportunities overseas are becoming limited. In these circumstances it is desirable that those doctors unlikely to progress smoothly up the career ladder should be informed of their limitations as soon as possible after they start specialist training. They would be able to move to another discipline while still young enough to cope with its academic demands and before they have progressed too far and become labelled as 'stuck' registrars.

It was decided in Reading, in an effort to respond to this situation, to initiate a 6-monthly reporting system on all anaesthetist SHOs. It was hoped that this would enable critical evaluation of their progress, focus attention on gaps in their training and bring areas of weak performance to their notice. The exercise also provided an opportunity to formalise the career counselling process.

Proforma

The proforma used is based on the military annual confidential report and is divided into three sections (Figs 1 and 2). The first contains 10 headings relevant to professional performance and ability; each is graded from weak to excellent. The subject is awarded from one to five points in each category, and these marks are added together to produce a total from which an overall grading is deduced using

the following formula: > 45, excellent; 36–45, very good; 26–35, good; 16–25, adequate; < 16, weak.

A space follows so that the initiator of the report can outline a pen picture of the subject. This may vary from a succinct phrase to a detailed exposition. The latter tends to be reserved for the less able and should concentrate on constructive criticism and advice about how improvements can be made and faults eliminated. Finally there is a series of questions, the answers to which form the basis of recommendations on the subject's future. These are subdivided under two headings that depend on whether the subject wishes to follow a career in anaesthesia or intends to enter general practice. The first reports were prepared in December 1986 and the exercise has been repeated at 6-monthly intervals ever since. To date 45 reports have been written on 17 SHOs.

Administration

Every 6 months all the consultants involved in junior staff training (11) and our senior registrar are invited to complete a proforma on each SHO (eight fulltime and a variable number of part-time trainees). For convenience this is carried out as at 31 December and 30 June each year. The faculty tutor then collates the completed proformae and produces a composite report. In the first section the mean marks awarded are given, in the second an overview of all the pen pictures is produced and in the third exact views are detailed (e.g. 7 × yes, 2 × no and 3 × undecided). The individual proformae are destroyed once this task has been completed.

Fig. 1. Confidential report form, page 1.

Surname:		Forenames:				
Age:		Date of report:				
Months in specialty:		Qualification dates				
Months in department:		Part I:				
		Part II:				
General report	Excellent	Very good	Good	Adequate	Weak	
	5	4	3	2	1	
Theoretical knowledge						
Practical ability/aptitude						
Clinical/diagnostic acumen						
Commonsense/judgement						
Initiative/organisational ability						
Reliability/punctuality						
Powers of expression	Oral					
	Written					
Professional manner						
General enthusiasm/interest						
Total points score:						
Overall grading:						

Fig. 2. Confidential report form, page 2.

Pen picture:	
<hr/>	
Recommendations	
1. <i>Career grade anaesthetists</i>	
Should this doctor be retained in the specialty?	Yes/no Undecided
Is this doctor likely to pass the Part III FFA examination in due course?	Yes/no Undecided
Would you be prepared to act as this doctor's referee, and support without reservation her/his application for promotion to registrar.	Yes/no Not yet
2. <i>General practitioner trainees</i>	
Would you be prepared to support this doctor's application for clinical assistant sessions in anaesthesia?	Yes/no Undecided
<hr/>	
Signed: _____	
Date: _____	

The composite reports are then circulated to each subject's personal mentor, and other consultants and the senior registrar are invited to peruse the master copies. The SHOs are presented with their reports by the faculty tutor in the presence of their personal mentor, at which time areas of misunderstanding are clarified, questions answered and career counselling provided. Should the discussions become contentious, which to date they have not, it is proposed to involve the chairman of the division as arbiter of departmental problems and the regional educational adviser of academic matters. At this interview each SHO is provided with a list of those consultants who have said in section three that they would be prepared to act as their referees and give unqualified support to any application they might make for promotion to the registrar grade.

Copies of the reports are kept to a minimum (three) in an effort to maintain confidentiality. Each SHO keeps one copy, a second is filed in their training record and the third is retained by their personal mentor.

Discussion

The lack of structure and career guidance traditionally associated with the early formative years of junior hospital doctors' training probably sprang from the belief that medical graduates were mature individuals with the necessary strength of character to organise their own professional progression to consultant status. This system did not

appear to hinder the more able, but in the battle for promotion the wastage among the remainder has proved unacceptably high. In an effort to bring some order to the situation in anaesthesia, Faculty district tutors were first appointed in 1979, and have been responsible for major improvements in training programmes. In addition some departments have responded to the Helliwell report¹ by designating specific consultants to act as personal mentors responsible for the welfare of junior staff. The introduction of a formal assessment programme for each trainee would seem to be a logical extension of this process, especially in the context of efforts to balance junior staff numbers against career grade vacancies.

Initially doubts were expressed as to the advisability of committing critical comments about professional colleagues to paper. However, there is no point in producing bland statements about the less able, as they are the very doctors that the system is designed to help. The composite report formed from the consensus view guarantees anonymity to each contributor, and it is made clear to the subjects that the faculty tutor has acted merely as an honest broker in fulfilling the role of collator. The compliance rate is very high with each request for completion of the proformae (83%), and very frank opinions are expressed.

All members of the division were involved in the initial discussions on this project, and it was significant that while many of the consultants expressed reservations the junior staff unequivocally welcomed its introduction. However,

Table 1. Career moves of Reading SHOs since December 1986.

	Number
Individual SHOs	17
Reports completed	45
SHOs still in post	9
SHOs departed	8
to teaching hospital registrar	2
to career general practice	1
advised to change career	5

following the first set of reports, those who had not fared as well as they had expected were not happy with the results. The role of the personal mentors proved invaluable at this stage and the importance of the special relationship they had built up with their charges was underlined. All the SHOs completed an anonymous questionnaire that detailed their views on the experience when the dust had settled. It was gratifying to find that they were unanimous in their wish to repeat the exercise, made several suggestions for improvement of the system's administration and had come to terms with the necessity to accept constructive criticism as part of the learning process.

It is not possible to discuss individual cases in this paper in view of the confidential nature of the reports. However, Table 1 details the career progress of the 17 SHOs who have so far received career counselling based on these reports. Of the five advised that their future prospects in anaesthesia were not good, two are now being vocationally trained for general practice, two have moved out of mainstream medicine and one has transferred to another hospital discipline.

Several minor modifications have been made to the proforma since its introduction and it will no doubt evolve further as additional feedback is processed. Two administrative details continue to give cause for concern as it stands. The first is that the production of an overview of the pen pictures is open to collator bias. This is probably

impossible to rectify, but continuity of faculty tutor appointments (3 years in the first instance) at least ensures that the same standard is applied to successive reports. The second is that the marks required in the overall grading system are too high at the excellent end of the scale and too low at the weak end; to date none of our SHOs have received either grading. This could be remedied, but at present it is felt that the mark necessary to obtain the accolade of excellence acts as an incentive for future improvement and the relative ease with which 16 or more points are obtained ensures that very few SHOs will be demoralised by receipt of their reports.

A similar proforma is used annually to report on our four registrars. Modifications have been made to allow assessment of research interest and initiators are asked to state whether they believe the subject will attain consultant status in due course. So far it has been used only on five subjects and it remains to be seen whether it will help identify the 'stuck' doctor and potential candidates for the staff grade.

The introduction of confidential reports has ensured that all our SHOs know exactly where they stand as regards their training and future within the specialty. It is no longer possible for square pegs to remain in round holes for any length of time, and no SHO is recommended for promotion to the registrar grade, either within or outside the Reading division, unless they are considered capable of passing the Part III FFA examination and are likely to progress to a senior registrar appointment. Unfortunately at present the same cannot be said for all registrars. Clearly if 'achieving a balance' is going to work it is essential that in future a minimal number of registrars become 'stuck' in their grade. Widespread use of a reporting system similar to the one outlined in this paper could ensure that this was the case.

Reference

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Special article

Second report from an anaesthetic reactions advisory service

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Summary

The continued work of the advisory service is reported; this now amounts to at least 300 enquiries about clinically severe adverse reactions each year. Thiopentone is still the most commonly associated intravenous induction agent with adverse reactions (76%), particularly when it is used with suxamethonium. Local anaesthetics account for between 5 and 10% reports.

Key words

Allergy; anaphylaxis.

Background

The National Adverse Anaesthetic Reactions Advisory Service (NAARAS) is a specialist service which offers analytical expertise and advice to the clinician faced with the frequently alarming, if not outright hazardous, anaphylactoid reactions to anaesthetic induction agents. A preliminary report on its activities was published in 1985.¹ The service operates from the Royal Hallamshire Hospital, Sheffield, within the terms of reference of the DHSS Supraregional Protein Reference Unit (PRU). The work of the PRU is primarily concerned with offering diagnostic advice based on the analysis of body fluids and tissue samples provided from a variety of pathological situations and sent by clinicians throughout the UK. Current workload is in excess of 60 000 requests for the whole unit per annum, 60% of which is of supradistrict origin.

The laboratory now examines in detail some 150 anaphylactoid reactions per annum that involve anaesthesia. It gives advice on at least twice that number without, or with minimal, laboratory analysis. This encompasses what the author considers to be only 5-10% of the overall morbidity problem within the United Kingdom, perhaps 5000-10 000 serious, operation-disrupting and (or) life-threatening reactions each year. The workload on documenting, analysis and reporting places an intolerable strain on NHS resources even at present numbers. For this reason NAARAS was instigated by the author in 1982 in order to spread some of the burden of cost to the pharmaceutical companies as well as to coordinate an expert panel of anaesthetists and other clinicians who could comment critically with regard to both the practice of anaesthesia and the case management.

Financial support

Finances are provided from an annual subscription, currently £400, from leading pharmaceutical companies. Companies originally agreed to support the venture for up to 3 years and NAARAS gratefully acknowledges the undermen-

tioned* organisations who have stayed loyally with us, despite in some cases having no direct commercial interest in anaesthesia itself.

Additional funds have come from contracted investigations carried out for some of these organisations through the Department's University affiliation. A development grant for a computer-based database has been provided by the University of Sheffield.

Support services

Investigations are carried out in the Protein Reference Unit (PRU) laboratory, Sheffield, following well established protocols.² The laboratory employs 25 full- and part-time staff and is equipped with modern aids to automated sample handling and analysis. The subspecialty NAARAS employs a part-time secretary and either a part-time clinical research assistant (SHO grade) or a trained laboratory scientist.

Progress is being made with a database entered on an Amstrad 1512. This has largely been the concern of the NAARAS secretary, Mrs M. Buxton, with advice supplied by Dr D. Walker, Lecturer in Anaesthetics, University of Sheffield.

The advisory panel is a group of clinicians and scientists who have offered their services. Members of this group are approached for advice on an *ad hoc* basis. Current membership of this advisory panel is: Professor R. S. J. Clarke (*Belfast*), Dr R. F. Cookson (*Janssen*), Professor G. Gowland (*Leeds*), Dr J. N. Lunn (*Cardiff*), Professor W. S. Nimmo (*Sheffield*), Professor J. S. Whitwam (*London*).

* Astra Pharmaceuticals Ltd, The Boots Company plc, Du Pont (UK) Ltd, Fisons plc, Glaxo Group Research Ltd, Hoechst UK Ltd, ICI Pharmaceuticals, Janssen Pharmaceutical Ltd, Eli Lilly and Co. Ltd, May & Baker Pharmaceuticals, Organon Teknika Ltd, Pfizer Ltd, Pharmacia Ltd, A. H. Robins Co. Ltd, Sandoz Pharmaceuticals Ltd, Wellcome Foundation Ltd.

Scope of service

NAARAS is concerned with all substances administered intravenously, before, during and after operation. Perhaps as a result of the growth in literature awareness, anaesthetic drug reactions are now perceived to be largely multifactorial events and reports show increased concern with pre-medication, antibiotics, analgesics and regional anaesthesia. Unfortunately, few reactions are reported in the literature, to the CSM or to us, which implicate plasma substitutes or radiological contrast media: adverse responses to these substances appear to be underreported to a serious extent.

Management. Protocols for the effective management of anaphylactoid reactions are emerging from the large number of reports which have accumulated over the last 10 years. Management, or rather mismanagement, of the anaphylactoid reaction is frequently the subject of costly litigation. The early use of fluids and intravenous adrenaline (1:10 000) must now be regarded as essential in all cases of anaphylactoid shock which present with acute bronchospasm and hypotension.

Laboratory requirements. The laboratory requirements are well documented;³⁻⁶ blood sampling on a sequential basis over the 24 hours after the reaction remains a priority.³ However, only blood samples collected into EDTA tubes are now required. NAARAS is investigating as a further refinement the use of a synthetic polycyclic protease inhibitor which greatly increases the stability of all blood samples, particularly those used for complement measurement, for plasma histamine measurements, and for blood coagulation factor studies. It is hoped that these blood collection tubes will be available commercially.

Relative involvement of anaesthetic induction agents.

Tables 1 and 2 illustrate the relative frequencies of hypnotic agents and neuromuscular blocking drugs respectively in *clinically severe* anaphylactoid reactions reported to Sheffield in the years 1985, 1986, 1987. As in the preliminary 1985 report¹ these Tables do not imply specific blame to the drug mentioned, simply that it was reported as used in the adverse incident. All the reactions were operation-disrupting, most were life threatening and a few patients died on the table or later in ITU. All these reactions were supported by sufficient clinical data, blood samples and sometimes autopsy specimens for an assessment to be made. The much larger group of patients referred to earlier in this communication with inadequate information are not recorded here. The probable causes of reaction are identified and reported to the individual anaesthetist.

General anaesthesia. Thiopentone remains the most frequently reported hypnotic in severe anaphylactoid reactions, mentioned in 70-80% of such reports each year. In terms of absolute numbers thiopentone reports also continue to increase.⁷ This could possibly be the result of increased use of NAARAS. However, it has previously been suggested⁷ that this could also reflect progressive immune sensitisation of the population with this drug, a process which may have taken many years to reach observable numbers. Some support for this view has recently come from McMaster University, Ontario (Dr J. Dolovich, personal communication) where serum from a genuine thiopentone-sensitive patient has been used for subsequent radioallergo-sorbent assay (RAST) testing of a population of anaesthetic reactors: antithiopentone antibodies were detected in some 30%. *Immediate* reactions to etomidate itself are rare: what appears to have been a genuine immune involvement to the drug reported in 1988 is currently under investigation, but such reactions seem

Table 1. Incidence of the various hypnotic agents in reports of serious anaphylactoid response to anaesthetic inductions.

	1985 (n = 66)	1986 (n = 85)	1987 (n = 90)
Thiopentone	56 (85%)	67 (79%)	68 (76%)
Etomidate	4 (6%)	10 (11%)	5 (6%)
Methohexitone	6 (9%)	4 (5%)	4 (4%)
Propofol	0	4 (5%)	13 (14%)

Table 2. Incidence of the various neuromuscular blockers in reports of serious anaphylactoid response to inductions of anaesthesia.

	1985 (n = 66)	1986 (n = 85)	1987 (n = 90)
Suxamethonium	28 (42%)	45 (53%)	48 (53%)
Alcuronium	14 (21%)	16 (19%)	11 (12%)
Tubocurarine	4	5	4
Vecuronium	1	9	10
Atracurium	8	5	11
Pancuronium	1	2	3
Gallamine	1	2	7

Table 3. Severe anaphylactoid responses that apparently involve local anaesthetics. From data presented by the author at an International Symposium, Controversies in Regional Anaesthesia, Leuven, January 1988.

Year	Bupivacaine		Prilocaine		Lignocaine
	* Caesarean	Other	Bier's	Other	
1985	3	0	0	0	2
1986	2	1	2	0	0
1987	8	0	1	0	1

* Some delayed up to 2 hours.

unlikely to occur at a frequency greater than 1:10.⁵ It is obvious that since the introduction of propofol in 1984 the initial low incidence of severe reactions has increased to what now (1988) appears to be a plateau. A similar pattern is shown by the neuromuscular blocker, vecuronium.

It appears at first sight that the Tables may simply represent the relative usage of the various drugs. This has been shown not to be the case with the neuromuscular agents: commercially available data for actual drug usage at various hospitals normalises the figures.⁸ This quite clearly placed suxamethonium as the most hazardous agent, with pancuronium as the safest. The drugs vecuronium and atracurium were identical and slightly less safe than pancuronium. Our data indicate that a serious reaction to suxamethonium (the most hazardous) occurs once in 4000 inductions when thiopentone is used as the hypnotic drug.

Local anaesthesia. We have not previously commented upon the problems of local anaesthetics (LA). The problems of LA are certainly fewer than those associated with general anaesthetic procedures and less frequently involve systemic response. However, they are more likely to reflect accident and local and regional central nervous system and cardiovascular system toxicity. The local effects reflect direct toxic effects of the drug on the tissues encountered by the injection. Neurotoxicity may be exaggerated by preservatives and particularly by adrenaline in the drug formulation. This does not seem to be very important in terms of dental procedures. In contrast, drugs used for spinal and epidural anaesthesia may generate hypotension as the result of local anaesthetic blockade of sympathetic fibres. The onset is often delayed (Table 3) and the reaction itself may be indistinguishable clinically from anaphylactoid response. Surprisingly (Table 3) LA reactions reported to Sheffield comprise some 5-10% of the total reports received.

Identification of causative drug

The author has seen no evidence to change his view that drug-specific, immune reactions account for no more than 30% of all serious anaphylactoid reactions. Nevertheless this minority should be identified wherever possible. The identification in the past has relied on examination of the clinical evidence, laboratory analysis and skin testing of the patient. There are several objections to the latter; the most obvious is that since the patient is tested several days or weeks *after* the incident the antibodies could have arisen as a result of the incident and *not* be its cause.

A commercial RAST assay is now available for suxamethonium as a result of cooperation between NAARAS and Pharmacia Ltd. This and a second assay, to alcuronium, are being evaluated. Plasma taken at the time of the incident may now be tested later in the laboratory for such antibodies. However, the reader should remember that the assumption is always made that their presence implies involvement in the aetiology of the reaction. Nevertheless, the fact that plasma may be tested in some period before an elective surgical procedure in a previous reactor to an anaesthetic or any other presumed high (drug) risk patient has not escaped the attention of the legal profession.

It is not possible in this short review to present full details of current studies on the use of the RAST identification procedures. Thiopentone and later possibly propofol and the regional anaesthetic drugs may also be included. However, as regards specificity to suxamethonium, in some 33 severe reactions in which suxamethonium was administered, 17 showed positive antibodies. Working by analogy with allergy to house dust mite and grass pollen, half of this number were of low titre and possibly therefore low clinical significance. Eight of the patients with high titres had raised plasma IgE level and had atopic history: they were all female (*cf.* similar observation based on intradermal testing).⁹ While suxamethonium and alcuronium may be readily distinguished within the same patient, in some cases low titres of antisuxamethonium may represent a mild degree of cross reactivity. This is also true for tubocurarine, but any cross reactivity between suxamethonium and either atracurium or vecuronium is very low indeed. No reactivity was found amongst a nonanaesthetic population (30 individuals) including 10 known atopic individuals with IgE titres greater than 1000 units/ml.

Conclusion

The service provides information to the clinician, to the pharmaceutical companies whose drug may be implicated, and the Committee on Safety of Medicines. Unlike yellow card reports made only to the latter, NAARAS provides both a critical laboratory-based evaluation of the causes of the initial reaction and suggest how best these may be avoided in *that* patient in the future as well as a valuable early warning system of trends to the pharmaceutical company. The latter may refer to general misuse of the drug in the clinical arena as much as a genuine drug risk.

Further expansion of the service will be difficult to achieve without overt support from either charitable foundations including The Association of Anaesthetists of Great Britain and Ireland and (or) the Department of Health.

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Letters must be typewritten on one side of the paper only and double spaced with wide margins. Copy should be prepared in the usual style and format of the Correspondence section. Authors must follow the advice about references and other matters contained in the Notice to Contributors to *Anaesthesia* printed at the back of each issue. The degrees and diplomas of each author must be given in a covering letter personally signed by all the authors.

Correspondence presented in any other style or format may be the subject of considerable delay and may be returned to the author for revision. *If the letter comments on a published article in Anaesthesia, please send three copies; otherwise two copies of your letter will suffice.*

Health Equipment (Dis)Information: HEI 166 Evaluation of heat and moisture exchangers

Health Equipment Information Bulletins (HEI) are produced to help and guide purchasers to make rational choices between various items of equipment. They are intended to offer an efficient and accurate method to allow comparisons of equipment which have been tested and evaluated with due regard to its use in the NHS. The value of the reports will depend on the evaluators using relevant tests to compare the devices.

A unique test method is used to evaluate heat and moisture exchangers (HMEs)^{1,2} in HEI 166; unfortunately, the chosen test method is not relevant when the clinical situation is considered. Eight groups at least have published methods over the last 30 years for testing HMEs experimentally with lung analogues which deliver air saturated with water vapour to the devices (a complete list of references is available from the author). It is possible to determine the 'efficiency' of the device by determining the reduction in water loss from the analogue lung. In addition to the credibility that methods which involve the use of a saturated test gas have acquired from previous workers, the committee responsible for the current draft ISO standard have specified saturated gas in that document. The evaluators who produced HEI 166 decided, for reasons which are not tenable, that when an HME is used clinically the expired air must become progressively desaturated. They then devised an analogue lung which fits in with their hypothesis and which is unable to produce saturated air at clinically relevant minute volumes.

The concept of significant desaturation of expired air is not tenable. Alveolar air, in the living organism, must always be fully saturated and forms the greater part of the expired air. The alveolar air cools in its passage through both natural and artificial airways, losing water vapour as it cools, but remains fully saturated. Published experimental data obtained when the original HME was used on a patient³ demonstrated that the expired air was fully saturated. Another study of intubated patients without a heat and moisture exchanger showed again that the expired air was fully saturated⁴ at all points from 10 cm below the carina to the expiratory limb of the system. We have confirmed, using a commercially available Dewpoint Hygrometer* with a heated sampling probe, that the expired air was fully saturated in every patient we tested with a hydrophobic HME (Pall BB50) in use for 24–48 hours and, in one patient, have found that the expired air was still fully saturated after the use of such hydrophobic HMEs for over 400 days. There can thus be no justification on clinical grounds for the use of an analogue lung model, as found in HEI 166, which does not provide fully saturated expired air.

The reply to a request to the DHSS for clarification on this point merely reiterated the points made in Appendix 2 of HEI 166, to the effect that the evaluators believe that expired gas is not necessarily saturated in the respiratory tract; no clinical or experimental evidence is advanced to support this proposition or to refute the findings of other workers.^{3,4}

However, is this experimental aberration important? The authors of HEI say that their results will be suitable for comparisons between devices. They refer in the article to acceptable levels of humidification which cannot possibly be achieved with their test rig since no HME can add heat and moisture to a system and the 'expired air' they provided from their test rig did not even reach the levels which they considered acceptable for 'inspired air'.

The effect of an increase in minute and tidal volume is

more important in reducing the efficiency and the level of humidification achieved when HMEs are compared. The test method used in HEI 166 cannot deliver sufficient water vapour to test even the smallest HME adequately and therefore indicates essentially the same level of efficiency at both high and low minute volumes. In other studies, including those carried out on patients,⁵ it is clearly shown that an increased tidal volume reduces the efficiency of HMEs. The limited output of water vapour from the test rig used in HEI 166 means that devices produced for paediatric use are apparently just as efficient at large minute volumes as they are when used in the range for which they are designed. This failure to determine the capacity of the HMEs makes comparison between the devices tested meaningless.

The DHSS, as the ultimate authority, have a responsibility to ensure that the information contained in HEI bulletins is relevant and applicable to the clinical situation. This could be best achieved by submitting the test protocols for peer review before time and effort are wasted in questionable studies.

HEI 166 does not help users to make rational informed choices between devices and its inability to determine the maximum enthalpy of the different devices makes the results positively misleading. The conclusions from these misleading results are now appearing in advertisements and the substance of the original report has been republished;⁶ this increased publicity is unfortunate because no indication is given of the controversial nature of the test method used or of the fact that three out of the seven manufacturers involved commented on the methodology. HEI 166 should be withdrawn from circulation until the tests can be repeated using a test method that involves the use of a lung analogue which produces conditions similar to those found in the clinical setting.

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A reply

Thank you for the opportunity of replying to Dr Bethune's letter.

The ISO draft test method was considered to be inadequate when the evaluation was undertaken in 1984. It has since been significantly modified.

The test rig model used in HEI 166 is based on that described by Weeks and Ramsey.¹ We accept that the test

* Dewpoint meter 3000, Michell Instruments Ltd., Unit 9, Nuffield Road Industrial Estate, Cambridge.

rig did not produce gas fully saturated with water vapour, but do not believe this will affect the results obtained for the comparative performance of the devices tested. The test rig does not, and never did, purport to represent an accurate patient model.

We would be grateful if Dr Bethune, or other workers, can send us valid scientific data that contradict the comparative results published in HEI 166.

The NHS Procurement Directorate,
14 Russell Square,
London WC1B 5EP

G. JUDGE

Reference

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Plasma bupivacaine concentrations after inadvertent intravenous injection

Toxic reactions to local anaesthetics are well described and usually occur as a result of accidental overdosage or inadvertent intravenous injection.¹ Fortunately most are mild in nature and few have catastrophic outcomes. We wish to report a case of inadvertent intravenous injection which was only revealed retrospectively after analysis of blood levels.

A 56-year-old 65-kg female presented for an elective Keller's procedure on the left foot. Formal consent was obtained to include her in a study on bupivacaine absorption after sciatic nerve blockade. Premedication consisted of temazepam 20 mg 2 hours before operation, and sciatic nerve block was carried out by the traditional posterior approach using a stimuplex peripheral nerve stimulator and 21-G insulated short-bevelled needle. (B. Braun Medical). When the optimum needle position was determined, 25 ml bupivacaine 0.5% was injected slowly over 2 to 3 minutes after negative aspiration for blood. Analgesia to pinprick, light touch, proprioception and motor blockade were assessed at 2-minute intervals for 40 minutes as part of the study. The patient remained cooperative and lucid throughout this time with no obvious signs of systemic toxicity. In particular there was no obvious shivering, twitching or dysarthria. Venous blood samples were taken from a large antecubital fossa vein at 0, 5, 10, 15, 20, 25, 30, 45, 60 and 90 minutes and bupivacaine was measured by high performance liquid chromatography. A block suitable for surgery was obtained after 30 minutes and the procedure was completed uneventfully. It was obvious on examination of plasma levels (Fig. 1) that inadvertent intravenous administration

had occurred although this was considered partial, since successful blockade was achieved. Previous studies have estimated that mild toxicity may occur at levels above 1.6 $\mu\text{g/ml}$ ² and that convulsions and more severe sequelae may be expected at 4 $\mu\text{g/ml}$ or above.³ The highest level measured was 3.8 $\mu\text{g/ml}$ at 5 minutes, but it has been shown that arterial concentrations may be 20–40% higher than venous⁴ and with rapid intravenous injection an even larger arteriovenous difference may be expected to occur.⁵ It is surprising therefore that no toxic signs were noted. The benzodiazepine premedication may have offered some protection against seizures and certainly would have masked early signs of sedation.

The case report also alerts us to the possibility of inadvertent intravenous injection occurring with a stimulator technique, where precise location of a nerve and immobility of the needle are necessary for success. The use of 120- and 150-mm needles, and the ease of vessel collapse with overvigorous aspiration, make detection of intravascular placement difficult. It is important as with other regional blocks to inject slowly, to maintain verbal contact with the patient and to avoid heavy premedication which may obscure early signs of toxicity. This report however demonstrates that clinical signs may not always be obvious even when levels approach 4 $\mu\text{g/ml}$. This may be particularly relevant if further nerve blockade such as femoral is planned, since knowledge of low systemic absorption from these sites may encourage the use of larger doses despite the recommended safe upper limit of 2 mg/kg. It seems sensible therefore to inject a local anaesthetic test dose, which contains adrenaline, while heart rate is monitored continuously as a more sensitive indicator of intravascular placement.

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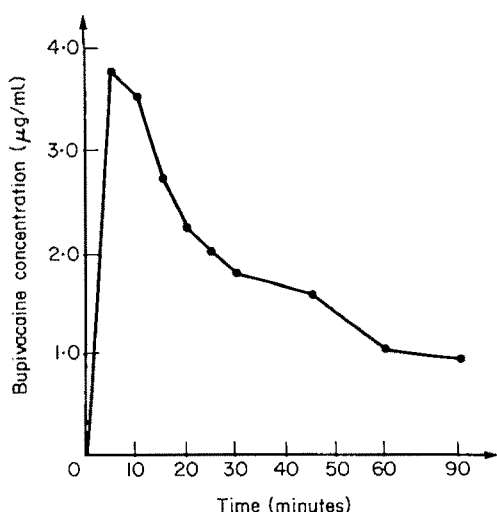


Fig. 1. Plasma bupivacaine levels after intravenous injection.

The relevance of volatile substance abuse to anaesthetics

In April of this year, a National Symposium on Volatile Substance Abuse (VSA) was held at Guy's Hospital, London. Participation was forthcoming from groups spanning the police service, teachers, voluntary organisa-

tions, politicians, pharmacists, forensic scientists, pathologists, psychiatrists, toxicologists, general practitioners and paediatricians. No other anaesthetists were present to my knowledge at this meeting. It dealt with a clinical field

which is relevant and of interest to us and one to which we are uniquely placed to make a valuable contribution.

Volatile Substance Abuse (or Glue Sniffing) is an increasing problem and now accounts for over 100 deaths per year in the United Kingdom.¹ The incidence of exposure in certain areas is estimated to be as high as 3 to 10% of school children,^{2,3} and a proportion of these will become chronic abusers. The long-term morbidity of this group is as yet ill defined.

The five main solvents abused are: toluene (in adhesives and spray paints), butane (gas cigarette lighter fuel), the fluorocarbons (the propellant in spray cans), trichloroethylene and 111-trichloroethane (in liquid papers and dry-cleaning fluid). All have anaesthetic properties at sufficient concentrations, which are only marginally higher than those that cause the desired hallucinations and euphoria. These concentrations are easily achieved using some of the most fundamental principles of vaporizers, such as 'huffing' from plastic bags and 'sniffing' from cloths or shirt sleeves, with an ingenuity that would surely make Morton and Wells proud. The latter two solvents have been used professionally in anaesthetic clinical practice. Trichloroethylene ('Trilene') is still currently used, and trichloroethane had to be hastily abandoned in the 1960s as a result of the very high incidence of ventricular arrhythmias.⁴ Trichloroethane, found in such products as Tipp-Ex, is structurally related to halothane.

The worst chronic abuser will consume vast quantities of these agents in daily sessions of up to 8 hours in an attempt to achieve continual intoxication, every day of the week, for months and possibly many years.⁵

There will be increasing numbers of these adolescent abusers who present for elective and emergency surgery with the increasing popularity of this practice. This problem will remain unknown unless its presence is elicited by direct questions. The organ toxicity of chronic abuse remains controversial, but there is mounting evidence of irreversible hepatic, renal, neurological, pulmonary, and cardiac injury. The anaesthetic implications of this toxicity

were illustrated by two cases reported last year, of life-threatening cardiac complications, following induction of halothane anaesthesia in patients with cardiac toxicity from trichloroethane exposure.⁶ One of the cases was a 14-year-old boy for routine tonsillectomy, and was unknown to be a trichloroethane abuser. He was discovered to be suffering severe ventricular arrhythmias after induction of anaesthesia. These complex arrhythmias did not respond to medication and the child ultimately required a permanent demand pacemaker. A possible interaction between halothane and the chronic myocardial damage produced by the trichloroethane, which resulted in acute deterioration, was postulated by the authors.

The relevance of VSA to the anaesthetist is not just one of an awareness of the potential organ toxicity these patients have incurred, our understanding of the pharmacology and administration of these types of agents make this profession particularly suited for research in this field.

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Neonatal responses to tracheal intubation

The interesting findings of Charlton and Greenhough (*Anaesthesia* 1988; **43**: 744-6) may be misplaced in today's climate of concern over neonatal responses to surgery. A number of questions require an answer if the safety of awake intubation in neonates is to be accepted and applied without reservation.

The authors state that they are unaware of any study about hypertension in response to tracheal intubation in this group. However, Raju *et al.*,¹ using an indirect transfontanelle method, have demonstrated an increase in intracranial pressure after awake tracheal intubation in comparison with intubation after curare. Unfortunately, no haemodynamic data are given in their paper, but premature neonates with fragile cerebrovascular systems are likely to be at risk.

Charlton and Greenhough purport to show that awake intubation is a safe technique, but in this small study the possibility exists merely that they have not detected a difference (type II error). Furthermore, they give no indication of the type of laryngoscope employed, whether it was uniform throughout, or whether the same anaesthetist performed all the laryngoscopies. It is known that in adults, laryngoscopy alone leads to elevation of arterial pressure,² and presumably any variation in technique or duration of laryngoscopy could influence this. In addition, we are not informed of the dosage of

thiopentone or pancuronium employed or the concentration of halothane used. This may influence the results since MAC decreases with decreasing gestational age.³

We are not justified, since the neonates in this study were greater than 3 kg and greater than 38-weeks' gestational age, in applying these findings to small neonates of low gestational age with a labile cardiovascular system. The authors state their view that premature babies behave in the same way as the neonates in this study. However, they may not be entitled to base their view on a mean systolic pressure change in only three subjects. This view is untenable in the light of other evidence which suggests that premature neonates differ from full-term neonates in terms of respiratory function,⁴ neurological maturity,³ and other postoperative complications.⁵

It has been asserted that we can no longer simply ignore such nociceptive activity,⁶ with increasing awareness of the response of neonates to painful and noxious stimuli. We may well be advised to adhere to the intuitive clinical beliefs of Charlton and Greenhough, as stated in their final paragraph, and avoid the use of awake intubation in this group of patients.

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A reply

We are well aware of the current concern about the responses of neonates to noxious stimuli, but we are equally concerned that those who advocate a change in practice do so on the basis of solid evidence. Dr Fell criticises our paper but fails to quote any data to refute our findings. He cites instead a study which did not measure blood pressures but looked at anterior fontanelle pressure (AFP),¹ a difficult measurement,⁷ but one believed to be an indirect correlate of intracranial pressure. This study did not record data on periventricular haemorrhage (PVH) but Dr Fell still uses it in support of his belief that 'premature neonates . . . are likely to be at risk'.

Our study of 45 true neonates (not 10 as Dr Fell has misread) is described as 'small', but in the study he refers to¹ only four out of 10 infants who were intubated awake. Two cases were actually having surgery for hydrocephalus. Postconceptual ages are not stated, nor is age distribution into awake and curare groups. PVH develops almost exclusively within the first 4 days of life⁸ but the infants in this study were aged 7 days to 10 months. Is this an adequate study on which to base our practice? A more recent paper,⁹ again using babies outside the time of risk, showed AFP changes to be not significantly greater than during normal crying. We do not dispute that AFP may increase but this may be as a result of venous pressure rises and not arterial hypertension, or, in some studies, due to the inclusion of babies outside the first 4 weeks' of life, whom we have shown do have an arterial hypertensive response to intubation.

We have not formally studied premature babies, for the reasons stated in our paper, during their time of risk, but none of the later features of this group quoted by Dr Fell (postoperative apnoea,⁴ lower MAC of isoflurane,³ and higher incidence of respiratory complications)⁵ give any grounds for assuming their response to intubation is different from the term babies of our study.

We anaesthetise babies before intubation because it is both humane and easier, and not because of any intuitive

belief about risks of PVH. Our paper makes no comment about risks of awake intubation but simply corrects a widely held belief about blood pressures. The measurement of blood pressure is not difficult and is surely performed during every neonatal anaesthetic. We hope our paper encourages those who have the data on premature babies to publish it.

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Alternative to practolol

In reply to Dr Johnstone's letter (*Anaesthesia* 1988; **43**: 714) we suggest that metoprolol (Lopressor, Geigy; Betaloc, Astra) may be an acceptable alternative to practolol. Both agents are selective beta₁ antagonists. Their blockade potency is identical and neither has any quinidine-like membrane-stabilising effects. Time to onset of blockade is similar for both, and metoprolol has none of the reported side effects of practolol (peritoneal fibrosis, oculomucocutaneous syndrome).

The elimination half-life of metoprolol is 3.2 hours as compared with 6-12 hours for practolol, but the former has active metabolites which prolong its duration of effect. Metoprolol is safer in renal impairment: 10% is excreted by the kidney as compared with over 90% in the case of practolol. The bioavailability of metoprolol is 100% while that of practolol is only 40%.

Metoprolol is available in both tablet and injectable forms, allowing one to change from parenteral to enteral routes as clinical conditions permit. Until the advent of

esmolol in these islands, we believe that metoprolol is a satisfactory substitute for practolol in the perioperative and intensive therapy settings and that the lack of intrinsic sympathomimetic activity in the former is of little clinical significance.

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Dural punctures

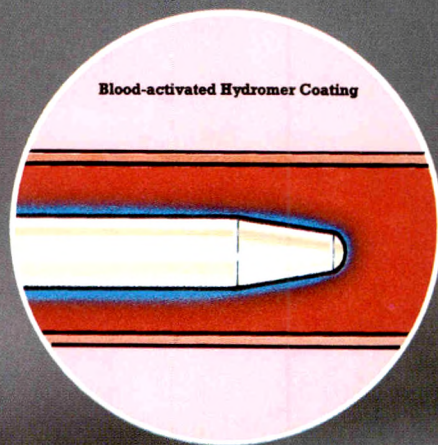
We have recently been studying the flow of fluids through dural punctures and during this study examined various puncture sites under the microscope. It was with interest

therefore that we read the recent paper 'Anatomical re-evaluation of lumbar dura mater with regard to postspinal headache' (*Anaesthesia* 1988; **43**: 635-7) and noted that the

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findings and conclusions of that paper did not correspond with our own observations.

We have examined puncture sites in fresh cadaver lumbar dura using 3-dimensional microscopy, and examined both sides of the dura under various combinations of top and through lighting. Examining the inside of the dura revealed no evidence of a flap or “tin-lid” phenomenon . . . capable of closing holes produced by the largest spinal needles,¹ as described in the above paper.

The dural collagen fibres do not all run parallel to each other; the dura consists of laminae, with the fibres in each individual lamina running parallel to each other, but the laminae crossing each other at varying angles produce a lattice effect.¹ Our impression after studying various needle types is that a different shaped hole is produced in each lamina—elliptical where the bevel splits the fibres, and more rounded where the bevel is at right angles to the fibres. The microscopic appearance of the hole is produced by the different hole shapes superimposed to form a tunnel. Thinner parts of the lumbar dura display a simpler hole type, of uniform shape throughout its length, that resembles the hole shapes seen in the individual laminae as above. If the hole angle does not exactly match the viewing angle, the inside of the hole is seen and produces a crescent which might be mistaken for a ‘tin-lid’.

We wonder whether the photograph in their paper simply shows the holes on the surface and parts of the inside of the dura. The accompanying figures show both the inner and outer surfaces of the dura at the same puncture site, and may help to clarify the above points.

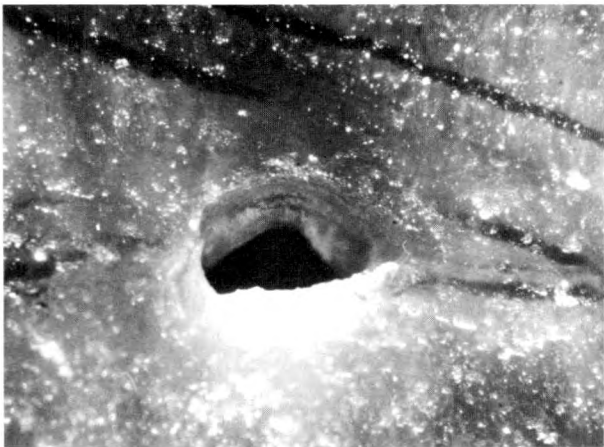


Fig. 1. Inner surface of dura showing puncture site.

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Reference

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A reply

The phenomenon of a so-called ‘tin-lid’ can be demonstrated on a videotape as can the shrinking phenomenon in thicker parts of the dura. Our photographs were taken using lighting from above. The quality of Figure 1 in our article was unfortunately not perfect. It came from a videotape and may have led the correspondent to assume that the tin-lid phenomenon is an artefact. The original tapes show that the dural flap was created by the use of different needles.

We confirm the authors’ observation about the different shapes of the holes, which are dependent on the diameter of needle sizes. If the hole angle does not exactly match the viewing angle, it is agreed that the inside of the hole produces a ‘crescent’. We would be pleased to make the videotape available to the authors.

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Fig. 2. Outer surface of dura showing same puncture site.

The use of perioperative opiates for laparoscopy

Laparoscopies are performed frequently on a daycase basis as Dr Davis and Millar stated in their recent letter (*Anaesthesia* 1988; 43: 796–7). In order to assess the current use of perioperative opiates in our unit to determine the suitability of the techniques in use for day stay patients, a retrospective survey was done of three groups of patients undergoing laparoscopy: those for diagnostic procedures, for investigations of infertility, and for sterilisation. There were 20 patients in each group (Table 1). All the procedures were performed during a 6-week period. The anaesthetics were given by both junior and

Table 1. Use of narcotics.

Laparoscopy	Diagnostic	Infertility	Sterilisation
For premedication	8	7	8
During operation	17	19	19
After operation	9	13	19
Number of doses			
1 dose	8	6	1
2 doses	9	9	11
3 doses	3	4	8
4 doses	—	1	—

consultant anaesthetists, and the results obtained from the anaesthetic record and the drug treatment card.

The narcotics used were papaveretum as premedication, fentanyl or alfentanil peroperatively, and papaveretum or morphine postoperatively. The results showed that all patients who underwent laparoscopy received at least one dose of a narcotic during the perioperative period and that those who had sterilisations required more analgesia than those having diagnostic laparoscopies; the infertility group was intermediate.

The use of the short acting opiates such as fentanyl and

alfentanil for day cases is not unusual, but the use of the long acting ones may be avoided because of the lack of data as to their suitability for these cases.

Ninety-five percent of patients for sterilisation required postoperative narcotics for analgesia, so it appears that if they are to be done on a day stay basis powerful analgesia must be provided, though which drug is the most suitable is yet to be decided.

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Malignant hyperthermia and myotonia congenita (Thomsen's disease)

We report a case of a 5-year-old boy with Thomsen's disease, who died after general anaesthesia with the clinical picture of malignant hyperthermia.

This child was born November 1982; at 10 months a diagnosis of Thomsen's disease was made based on the findings of myotonia and muscular hypertrophy. The serum creatine phosphokinase (CPK) was elevated (1900 IU/litre). The electromyogram tracing was typical of myotonia. Treatment with mexiletine was started and resulted in amelioration of the symptoms. These were aggravated by cold, stress and hyperthermia.

In October 1987 he presented with a fractured distal radius and ulna which was initially reduced, and immobilised in plaster. However, because of malalignment of the distal radial fragment, it was decided to attempt a closed reduction under general anaesthesia. In addition, because of recurrent nasopharyngitis, a tonsillectomy and adenoidectomy were planned simultaneously. The patient was in good general health, with height, weight, and psychomotor development within the normal range, except for the hypertrophic musculature. The CPK was 538 IU/litre.

Pre-anaesthetic medication consisted of: 20 mg dantrolene by mouth 9.5 and 3.5 hours before induction and 120 mg rectal pentobarbitone. A brand new anaesthetic system was used. The general anaesthetic included thiopentone (total dose 500 mg), dextroramide (0.75 mg), tracheal intubation and assisted ventilation with a mixture of oxygen and nitrous oxide (F_{IO_2} 0.5). The patient's temperature initially was 37.8°C. Anaesthesia and operation progressed uneventfully and lasted 1 hour 45 minutes. His rectal temperature was 37°C at the end of the operation. The patient was drowsy, but reactive, in the postanaesthesia care unit. Seven hours after anaesthesia, he developed spasms in his leg muscles, and profuse sweating. The rectal temperature rose to 37.6°C, the arterial pressure was 137/70 mmHg, the heart rate 160/minute (sinus rhythm). Arterial blood gas analysis revealed a pH 7.26, P_{CO_2} 6.18 kPa, a base deficit 6.5 mmol/litre, serum potassium 4 mmol/litre, CPK 6400 IU/litre. He was immediately treated with intravenous solutions of crystalloid and glucose and mexiletine through the nasogastric tube. Eleven hours after operation his rectal temperature was 38.8°C and the muscle rigidity increased. The arterial blood gas analysis then revealed a mixed respiratory and metabolic acidosis: pH 7.16, P_{CO_2} 7.83 kPa, base deficit 8 mmol/litre. The clinical situation deteriorated rapidly, reflected by a temperature which reached 39.5°C, and severe, diffuse rigidity, notably of the thorax. Acute respiratory insufficiency necessitated reintubation and mechanical ventilation of the lungs. Ice cold sodium chloride gastric lavage, and intravenous sodium bicarbonate were given. A few minutes later circulatory arrest occurred and required external cardiac massage. Simultaneously dantrolene 1 mg/kg was given intravenously every 5

minutes to a total of 10 mg/kg. The rectal temperature finally reached 40.8°C, and the extreme muscular rigidity required maximum inflation pressure on the mechanical ventilator. In spite of the resuscitation efforts, the situation deteriorated with severe metabolic acidosis (base deficit 20 mmol/litre). The serum CPK was above 11 500 IU/litre. The centre temperature decreased to 36.8°C by the 14th hour; the rigidity was extreme which made pulmonary ventilation almost impossible. A final cardiac arrest resisted all efforts of resuscitation. The autopsy did not reveal a specific lesion.

Malignant hyperthermia is a genetic anomaly whose mechanism has not been completely clarified. The links with particular congenital muscular diseases are often difficult to establish.¹ The clinical cases reported have rarely had the results of *in vitro* muscle biopsy tests to confirm the susceptibility to malignant hyperthermia. In a situation where muscular disease and malignant hyperthermia are combined, three explanations are possible: the association is coincidental and independently inherited; the abnormalities of skeletal muscle in patients with myotonia congenita may lead to both physiological abnormalities and anaesthetic events similar to malignant hyperthermia; patients with myotonia congenita may have an increased susceptibility to malignant hyperthermia. Gordon *et al.*² report three clinical cases of myotonia with positive *in vitro* caffeine tests. Heiman-Patterson *et al.*³ report a case of two sisters in which the diagnosis of myotonia was proposed after authentication of muscular hypertonia in which suxamethonium was used during general anaesthesia. Contracture of muscle biopsies taken occurred when exposed to halothane in the two cases. These two reports clearly demonstrate that patients suffering from myotonia congenita react positively to tests of malignant hyperthermia susceptibility. Our observation, clinically associating myotonia congenita and malignant hyperthermia in the period immediately after general anaesthesia supports the possibility that the association does exist and is intended to alert those involved with patients afflicted with these rare diseases to examine them very closely during general anaesthesia.

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Anaesthesia for valvuloplasty

We read with interest the article by Chaffe, Fairbrass and Chatrath (*Anaesthesia* 1988; 43: 359–62) and concur with most of their comments on anaesthetic management. Our experience over the past two years is presented in Table 1.

Table 1.

Pulmonary stenosis	39 cases
Aortic stenosis	2 cases
Coarctation of aorta	1 case
Average age, 34 months (range 2 days–15 years); average length of procedure 115 minutes (range 45–225 minutes).	

Our anaesthetic technique is broadly similar but differs in some respects. It has been a policy to monitor arterial blood pressure directly with a radial line since rapid fluctuations in blood pressure occur around the time of valve dilatation. It is an advantage to the operator to be able simultaneously to compare systemic and right ventricular pressures in the assessment of the valve for dilatation. We were puzzled by the authors' contention that blood pressure could be monitored through the catheter. This is certainly not the case in pulmonary valve dilatation when only the venous side of the circulation is catheterised.

Controlled mechanical ventilation of the lungs is without doubt superior to manual ventilation in providing cardiovascular and respiratory stability. This is most important in investigative procedures of this sort. Patient temperature is maintained by a heated water blanket and humidified inspired gases, while rectal and skin temperature are monitored. This has been found to be a satisfactory way to minimise the discomfort associated with working in a heated laboratory wearing a protective lead apron.

This approach reflects the fact that our patients have tended to be younger and therefore smaller; two were only 2 days old. Consequently, the procedure is more difficult and certainly longer. Haemorrhage and hypovolaemia have been the major problems encountered and we recommend that cross-matched blood be readily available.

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A. AITKEN

This paper (*Anaesthesia* 1988; 43: 359–61) was interesting and I would like to comment. The monitoring of arterial blood pressure was by a cuff and later by a transducer attached to the cardiac catheter. These patients were having right-sided angiography so I assume that there was a second cardiac catheter introduced into the femoral artery. We have found that by the introduction of a radial artery cannula and monitoring pressure by this for right-sided angioplasties, no invasion of the femoral artery is

necessary: this leads to a potential reduction of blood loss which is one of the commonest problems mentioned. The arterial pressure can be monitored during the period of balloon inflation as well as during manipulation of the valvuloplasty balloon catheter for aortic valve dilatation. One patient had tachycardia but this has rarely been my experience and I find that bradycardia is the commonest problem with pulmonary valve stenosis especially when right ventricular outflow tract stenosis is present.

When the balloon is in an already very hypertrophied outflow tract, passage during the period of inflation and deflation causes further obstruction and the obstruction is for a longer duration because of the increased length of the stenosis. One can also use the pulse oximeter in this situation; we have found that during the very limited period that the angioplasty dilatation causes obstruction there is minimal change except when there is a long inflation during aortic valvuloplasty.

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I. McLELLAN

A reply

Thank you for allowing us to comment on the points raised by Dr McLellan and Drs Rowbottom and Aitken. We were pleased to see that broadly similar techniques are being used by all of us.

We would certainly agree that a Servo 900c would give superior stability, and as we mentioned, now that we have a ventilator (Sheffield Infant Ventilator) we too are ventilating our patients' lungs. We have tried using a heated blanket to maintain temperature, but have unfortunately not had such good results so have to endure the discomfort of a heated laboratory.

We also mentioned in the original article that we crossmatch blood for arterial approaches, but as we are in such close proximity to the Regional Transfusion Centre, blood can be rapidly obtained if it is just grouped and saved for the venous approaches.

We have not used direct arterial pressure monitoring other than through the catheter used by the cardiologists because we considered that the additional risks of cannulation of the radial artery outweighed the benefits obtainable, especially since during the period of balloon inflation, we know that the pressure is going to decrease, and that the best treatment is to deflate the balloon. Hence, inflation time is kept to the absolute minimum.

We agree wholeheartedly that a pulse oximeter could be used, and look forward to the day that we have one available for these patients.

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R.R. CHATRATH
A. CHAFFE

Acute inversion of the uterus at Caesarean section

The case report by Drs Emmott and Bennett (*Anaesthesia* 1988; 43: 118–20) was interesting. In view of the apparent rarity of this complication, I report a similar case which happened just a few weeks after their publication. A 16-year-old primigravid female was induced at 38 weeks' of pregnancy for intra-uterine growth retardation and diminished liquor volume. There was fetal distress which necessitated emergency Caesarean section within 4 hours of artificial rupture of membranes. General anaesthesia was induced and a live, but floppy, male infant was delivered 9 minutes

later through a lower segment uterine incision. Ten units synthetic oxytocin were given intravenously after delivery. Papaveretum 20 mg was administered intramuscularly.

Gentle cord traction was applied; complete uterine inversion occurred during this manoeuvre. The placenta and membranes were rapidly removed and the uterus was re-inverted manually—all within 5 minutes of delivery.

There was no hypotension or significant alteration in heart rate. Blood loss was certainly not excessive (estimated at 300 ml) and a total of 1500 ml crystalloid was

given throughout the procedure. There were no maternal postoperative complications.

This report therefore, confirms the absence of excessive bleeding noted in the previous cases of uterine inversion at Caesarean section. The haemodynamic stability of this patient was notable and re-inversion took place within 5 minutes. Indeed, had I not noticed Emmott and Bennett's

paper I would probably have thought no more of my own case (a patient with vaginal uterine inversion tends to be far more memorable!). One wonders whether the 'rarity' of this event is, in part, the result of under-reporting?

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A.P. MASTERS

Propofol for electroconvulsive therapy

The recent article by Rouse [*Anaesthesia* 1988; 43 (Suppl.): 61-4] which compared propofol and methohexitone for electroconvulsive therapy was interesting. There seem to be a number of factors which were ignored in the design of the study.

There is evidence that during a course of ECT, the duration of the fits and the EEG patterns become modified by the treatment.^{1,2} This largely invalidates a crossover study because the results in any individual are modified as the course of treatment progresses.

Dr Rouse used gross duration of seizure as a marker, but Fink and Johnson demonstrated that an isolated forearm technique shows a better correlation with EEG changes.³ The paper does concentrate on the importance of current, rather than duration of seizure. There is, however, a school of thought which considers that a course of ECT with a total duration of fit of less than 210 seconds is associated with a poor response to treatment.⁴

It is extremely difficult to investigate this area where the anaesthetist may modify the effects of treatment. This study, like many in the anaesthetic literature, has concentrated on fit time and recovery. Should we instead concentrate on overall outcome of treatment, and investigate the changes that different anaesthetic agents make to this?

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4. MALETZKY BM. Seizure duration and clinical effect in electroconvulsive therapy. *Comprehensive Psychiatry* 1978; 19: 541-50.

A reply

Thank you for the opportunity to reply to the points raised in the letter from Dr Adams.

This study was set up to compare the anaesthetic and recovery profiles of propofol and methohexitone. The different durations of fits after each drug became apparent during the course of the trial and it was decided to take some additional measurements. It was considered that this could be done without altering the original protocol. There are some disadvantages in a crossover study because duration of fits may decrease to the extent of a reported 24% over a complete course of ECT.¹ However, other factors such as mood also alter during the course of treatment and it was believed that a crossover design would help to eliminate any effect of these.

Fink and Johnson's² isolated forearm technique was originally devised to confirm that convulsive activity had

occurred since there were many cases of failure of seizure. They did their work when unilateral ECT was in vogue and it was important to discover whether there had been bilateral activity in the cerebral hemispheres. Consequently they isolated the arm on the same side as the electroconvulsive stimulus. One of the main aims of my study was to measure changes in the blood pressures of the patients during ECT. Isolation of the other arm for part of the time would have interfered with this.

Fink and Johnson also give an account of the EEG. 'Electrodes of the MEECTA EEG amplifier were applied to the patient's scalp over the dominant hemisphere. The instrument begins to record cerebral electrical activity after the seizure-inducing currents have been applied. The duration of seizure is measured visually from the paper record, in seconds from the time of induction of the recording to the termination of large electrical discharges. In about two-fifths of the records, the termination is abrupt, and the estimate of the duration is defined clearly. In the remainder, high-voltage activity trails off into either lower-voltage slow waves or alpha waves, and the termination is defined arbitrarily, with varying difficulty by the reader.'

This finding is very similar to my own when using the isolated cuff method to measure duration of fit. The method can only be crude. Sometimes the fit ends abruptly and the end-point can be assessed fairly accurately, depending on the reflexes and skill of the observer. On other occasions a patient goes on twitching very slowly and irregularly for some time and it can be difficult to identify the cut-off point accurately. Incidentally the cut-off point after propofol is usually very abrupt and consequently easy to determine.

The sentence in my paper about the importance of the current, rather than the duration of seizure, refers to a study of the effects of titrating the current until a fit was produced.³ Some workers consider that, since ECT is in itself an anticonvulsant, it is not the duration of seizure that is important therapeutically but the metabolic process in the brain that stops the fit.³

There have been other reports of a reduction of seizure duration with propofol.⁴ The difference in durations after the two drugs was so great that their inclusion seemed worthwhile. There is obviously a lot of work to be done to determine whether this feature of the drug hinders recovery from the psychiatric effects of ECT.

The only certainty about ECT is that there will be several schools of thought about every aspect of it and I agree that investigation is difficult because there are so many variables, including, as Dr Adams suggests, the anaesthetist. A colleague now retired was strongly of the view that ECT had a much greater therapeutic effect in the days when no anaesthetic was given at all, but the local ethics committee would need persuasion to allow such a study. However, a study to determine whether the shorter duration of fit after propofol affects the therapeutic outcome is under consideration.

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Edrophonium–hyoscine butylbromide mixture in neonates

We have previously reported edrophonium–hyoscine butylbromide mixture as an alternative to edrophonium–atropine mixture for the reversal of neuromuscular blockade in infants and children.¹ We tried this mixture recently in neonates (*n* = 19; mean age 5.4, SD 6.4 days, weight 2.8, SD 0.5 kg). At the end of the operation after oxygen, nitrous oxide, curare anaesthesia, edrophonium (1 mg/kg) and hyoscine butylbromide (0.4 mg/kg) mixture was administered intravenously over 30 seconds and heart rate changes were recorded with electrocardiogram. The heart rates remained stable (Table 1). Edrophonium–

hyoscine butylbromide mixture can be administered safely to neonates with minimum heart rate changes.

Ibaraki Children's Hospital, Mito, 311-41, Japan M. YAMASHITA K. TAJIMA

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Table 1. Heart rate values (beats/minute) during and after edrophonium–hyoscine butylbromide mixture in neonate.

	During intravenous administration				After intravenous administration									
	Seconds				Seconds						Minutes			
	0	10	20	30	10	20	30	40	50	60	2	3	4	5
Mean	171	169*	169	169	172	172	172	173	172	173	171	169	167	166
(SD)	(17)	(18)	(16)	(16)	(17)	(19)	(18)	(18)	(18)	(20)	(20)	(18)	(17)	(16)

* *p* < 0.05 as compared with initial value (Student's paired *t*-test).

Femoral nerve block after inguinal hernia repair

Drs Lewis and Fell (*Anaesthesia* 1988; **43**: 249) have described the development of motor and sensory changes that result from femoral nerve block in patients who undergo inguinal hernia repair under ilio-inguinal block and postulated that the local anaesthetic might spread to the groin, from the injection site. A recent case has suggested a different aetiology.

A 56-year-old man underwent right inguinal hernia repair, for the third time, by an experienced surgeon. The anaesthetic consisted of lumbar epidural block and midazolam sedation. When the block wore off, the patient complained of marked right-sided quadriceps weakness and numbness of the anterior thigh, with great difficulty in walking. The surgeon attributed the problem to the epidural, despite the peripheral nature of the lesion, until electromyographical studies revealed a femoral nerve block and subsequent surgery was required to remove a suture from the femoral nerve! The patient made a slow and incomplete recovery.

This is an extreme example of femoral nerve block after inguinal hernia repair, but it is suggested that mild degrees

of conduction neurapraxia might result fairly frequently from the retraction and trauma of surgery and could have easily accounted for the 12 hours of nerve block in the two patients reported by Lewis and Fell. This is rather a long duration for plain bupivacaine (0.375%) block of the femoral nerve, as postulated.

One of my neurosurgical colleagues (Dr P. Blum) informs me that whilst the femoral nerve is particularly vulnerable to this sort of surgical trauma, he cannot visualise any pathway whereby local anaesthetic could diffuse from the block site to the femoral nerve. This opinion is based on his considerable experience of groin exploration for ilio-inguinal and ilio-hypogastric neuromas. Perhaps, this is another example of the anaesthetic being unfairly blamed for postoperative neurological symptoms.

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Anaesthesia in the testicular feminisation syndrome

Two sisters, aged 16 and 18 years, who weighed 50 and 54 kg respectively, presented with primary amenorrhoea. Their external appearances were of apparently normal females but they each had scanty pubic hair, a short blind vagina and no uterus. Genetic examination showed an XY karyotype; the diagnosis of testicular feminisation syndrome was made and they were scheduled for laparotomy to remove intra-abdominal gonadal tissue. There is one previous case report of anaesthesia for patients with the testicular feminisation syndrome¹ which described immaturity of the larynx and the necessity for a smaller than normal tracheal tube (6.5 mm in an 18-year old, 65-kg

patient). Mindful of that report, a range of different sizes of tracheal tubes was prepared. No difficulty was experienced, however, with the insertion of an 8-mm cuffed Portex tracheal tube, although only 2 ml of air was required in the cuff to ensure an airtight seal. Subsequent auscultation of the chest revealed air entry to the right side only. The cuff was deflated and it was found to be necessary to withdraw the tube until the cuff was at the level of the cords before bilateral lung ventilation was achieved. The cuff had therefore to remain deflated to avoid damage to the vocal cords. The same problem was noted with the other sister.

These two case reports differ from the previous report in that a smaller diameter tube was not essential. An 8-mm tube was clearly too long. It is likely that a smaller diameter tube, which has a shorter length between the tip to the top of the cuff, would be preferable with patients with this syndrome.

There is one other consideration in these patients. It is likely that they are unaware of their exact genetic status (this was noted to be the case in the previous report) or at least do not have a full understanding of the situation. It is therefore unwise to enter into discussions with the patient

with regard to the nature of the operation or of the complex endocrinological problems, but to leave such matters wholly to the discretion of an appropriate specialist.

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Another tale of the unexpected

This is a report of an unusual occurrence in an 84-year-old female patient with a fractured right neck of femur (of 4 days' duration) booked for a Jewett nail and plate. Pre-operative investigations included an ECG that showed normal sinus rhythm. A chest X ray showed kyphoscoliosis with scoliosis concave to the right, but no other abnormality.

Haematological and biochemical tests were essentially normal and the patient was assessed as fit for anaesthesia. Premedication was with papaveretum 5 mg and atropine 0.3 mg.

One hour later in the anaesthetic room her blood pressure was 149/80 mmHg, pulse 75/minute, and JVP prominent while lying flat; the ECG monitor showed sinus rhythm, and there was no respiratory distress. The patient was pre-oxygenated for 3 minutes while an intravenous infusion was established. Anaesthesia started with propofol 60 mg followed by suxamethonium 75 mg. An 8.0-mm Argyle tracheal tube was passed and the site checked. Fentanyl 0.05 mg was given intravenously and an infusion of compound sodium lactate started.

The patient was taken into the operating theatre and transferred from the trolley to the operating orthopaedic table. Anaesthesia was continued with N₂O:O₂ 4:2 litres/minute and atracurium 10 mg was given intravenously. Traction was applied to her legs with the Eschmann extension table. The blood pressure monitor recorded systolic pressures of 100, then 60, then 30 mmHg. The cuff was resited and the monitor reset to cycle at one-minute intervals. Oxygen 100% was given and manual ventilation started, allowing time for venous filling. Radial, carotid, then femoral pulses were sought and all were absent. Jugular veins were still prominent but not distended. ECG continued to show a rate of 75/minute with P-waves present, then a salvo of ventricular arrhythmias was followed by sinus rhythm with T-wave inversion.

The possible presence of pulmonary hypertension and a cardiac arrhythmia prompted the use of a sympathetic agonist. Intravenous dopamine 1.6 mg caused the blood pressure to increase to 160/80 mmHg promptly; full pulses returned, regular and at 120/minute. ECG monitor showed P-waves but T-wave inversion persisted. The blood pressure started to decrease again after 5 minutes to 100 systolic and a further 0.8 mg dopamine was given.

The differential diagnosis was acute pulmonary embolus; myocardial depression from drugs; drug anaphylaxis (although skin colour was white not red and there was no bronchospasm). Breath sounds and airway pressure was unchanged. The heart rate was unaltered until the salvo of ventricular arrhythmias occurred. There was impaired venous return but intrathoracic pressures had remained the same. Myocardial infarction seemed an unlikely cause since the ECG changes happened after the hypotensive onset. Autonomic neuropathy was another possibility but the patient was not a diabetic, nor on medication and there was no bradycardia.

The procedure was abandoned because we did not know

the aetiology of this incident; neuromuscular blockade was reversed; recovery was rapid and the patient was disappointed her hip operation had not occurred. She had no chest pain. A 12-lead ECG showed T-wave inversion in all chest leads. Blood was taken for cardiac enzymes, IgE and complement reactions.

Dopamine was not required again. She was discharged from the recovery ward after one hour of stable vital signs and the urinary catheter had drained 60 ml/hour. Three hours after the hypotensive episode blood was taken for complement reactions; the vital signs were still normal and the patient was quite lucid and understood there had been some unusual episode under anaesthetic. She could give no relevant history of fits, faints or blackouts. The consultant anaesthetist on call considered that drug-induced histamine release was the most likely explanation.

Twenty-four hours after the hypotensive episode a 12-lead ECG showed no evidence of ST to T-wave disturbance at all. Vital signs were steady. The patient was prepared for theatre again after suitable consultation and in the absence of any sequelae.

The patient was premedicated with papaveretum 5 mg and atropine 0.3 mg. Dopamine injection was immediately available, ECG and blood pressure monitoring were started, pre-oxygenation for 3 minutes was followed by intravenous induction using 200 mg thiopentone followed by 6 mg pancuronium. Oxygenation by mask continued; 0.05 mg fentanyl was given and tracheal intubation was with 8.0-mm Argyle tracheal tube. The blood pressure decreased by 10 mmHg to 130 mmHg after the thiopentone and the pulse rate increased by 10/minute to 90/minute after the pancuronium. The patient was transferred to the orthopaedic operating table after 10 minutes. Hypotension again progressively developed within 2 minutes of the patient being repositioned on the Eschmann extension table. Intravenous dopamine 1 mg caused the systolic pressure to increase to 160 mmHg, and a tachycardia, 120/minute, occurred. One ventricular ectopic was seen but there was no T-wave inversion. The surgeon was advised to proceed. Further episodes of hypotension every 5 or 10 minutes were managed with dopamine.

Blood loss was 150 ml; the patient awoke in theatre at the end of the procedure and once transferred to the theatre trolley required no further sympathomimetic support. Progress to date has been uneventful. Laboratory assays of IgE and complement were within normal limits.

This experience reinforces the adage that 'Eternal vigilance is the price of safety', emphasises both the virtue of manual palpation of the pulse in addition to ECG and blood pressure monitors, and the need for support procedures so that a rapid response to sudden unexpected changes in a single variable can be achieved.

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B. LAWRENCE

Anxiety and informed consent

We imagine that many clinical investigators will have been dismayed by the findings of the recent study by Antrobus (*Anaesthesia* 1988; 43: 267-9) who demonstrated that seeking informed consent resulted in 23% of patients declining to take part in an (hypothetical) study of anxiolytic premedication. Moreover the decliners were demonstrably more anxious, so those most likely to show reduction in anxiety and potential benefit from any reduction would not be included in such studies of efficacy of premedication in which informed consent was sought.

We have recently completed an investigation of a novel anxiolytic agent in daycase patients in whom informed consent was sought by sending the patients a letter which detailed the aims of the study and how the patients would be assessed. The letter was sent the week before surgery to allow plenty of time to consider the request, and queries were invited on the day of surgery in the Day Bed Unit, at which time consent was obtained.

Fourteen out of the 134 patients (10%) who received a letter declined to take part in our study. This is very different from the response obtained by Dr Antrobus who had 10 refusals out of 43 (23.2%). All those who declined appeared calm and we did not attempt to study them but it would have been interesting to see if they had heightened anxiety scores. Antrobus did not find a significant effect of scale of operation on the pattern of consent, although we suspect that a larger study might reveal such an effect.

Nonetheless it would appear that granting of informed consent by patients to take part in clinical studies is more likely to occur if sufficient time is allowed for consideration of the request than if an instant response is required.

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J. BIRD

Consent and the anaesthetist—use of a videofilm

The editorial on this subject (*Anaesthesia* 1988; 43: 265-6) was interesting and stimulating. The procedure of obtaining consent needs improvement since the consent is not obtained by the anaesthetists and is not for anaesthesia. The current forms neither include any explanation about any aspect of the administration of anaesthesia nor any evidence about the adequacy of this explanation. This could, hypothetically, be extrapolated to an assertion that no consent for anaesthesia is sought or obtained! The basis for this extrapolation is the emphasis in the editorial for the need for contemporaneous and valid evidence that consent was obtained. Most anaesthetists, however, junior and senior, usually ask the patients about their previous anaesthetic experiences, offer explanations about regional and (or) general anaesthetic and arrangements for postoperative pain relief, and answer patients' queries. This is oral and is not recorded in the present format of the consent form. Furthermore, the consent is almost always obtained by the surgical team before the anaesthetist's visit, which means that patients do sign the consent form without knowing the details about anaesthesia!

One possible improvement in the system for obtaining consent for anaesthesia might involve the use of a videofilm. The film should offer a comprehensive explanation for the patient of all relevant procedures. Thus patients would be better informed and would be able to direct specific questions to the anaesthetist. Consent would then be informed. The collective wisdom of the Association of Anaesthetists of Great Britain and Ireland and (or) The College of Anaesthetists, could be incorporated, perhaps in consultation with lawyers, so that the actual wording and the type and extent of explanations offered to patients were appropriate. This could be supplemented, if necessary, by individual clinical judgement based on the individual case.

The consent form would also need modification to include reference to the use of video film and the interview with the anaesthetist before the form was signed. The film could be used as evidence by the courts. Thus both the cardinal points of the editorial, proper explanation and evidence, would be upheld in a prospective manner and an era of real consent for anaesthesia could begin.

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G.N. KALLA

A reply

Dr Kalla raises an interesting and valid point. In agreeing to elective surgery one presumes (but admittedly it is something of a presumption) that patients appreciate that they will be undergoing a general anaesthetic. Thus their consent to the operative procedure must surely be taken to imply their consent also to the anaesthetic. On the whole our experience in the Medical Protection Society is that litigation seldom arises which is even remotely attributable to the lack of a specific consent to anaesthesia. Thus on practical and indeed legal grounds I cannot really believe that there is a pressing need in the current climate in England and Wales for a separate specific consent form for the anaesthetic as well as for the surgery. However, if the anaesthetic is to be unusual in any way (one thinks of hypotensive anaesthesia for cosmetic surgery, for example) perhaps there is a duty to explain it and for the anaesthetist to make an adequate note in the medical records.

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R.N. PALMER

Epidural anaesthesia and instrumental delivery

Argument still persists about the relationship between the use of epidural analgesia in labour and increasing use of forceps delivery, most recently in the altercation between Dr F. E. Luscombe and Drs J. A. Hicks and J. G. Jenkins (*Anaesthesia* 1988; 43: 800-1). One of the papers at the centre of the discussion originated from this hospital,¹ so here is a comment and a reply to some of the criticism.

The whole problem of whether there is an association

between epidural use and increased forceps delivery is bedevilled by the lack of a prospective contemporaneous, controlled study. Indeed, it is difficult to see how it could be arranged. Early reports on the effects of epidural analgesia in labour²⁻⁴ described the outcome of those who received epidural analgesia. A high proportion of forceps deliveries is hardly surprising, since most epidurals were used in problem patients with a clear indication for

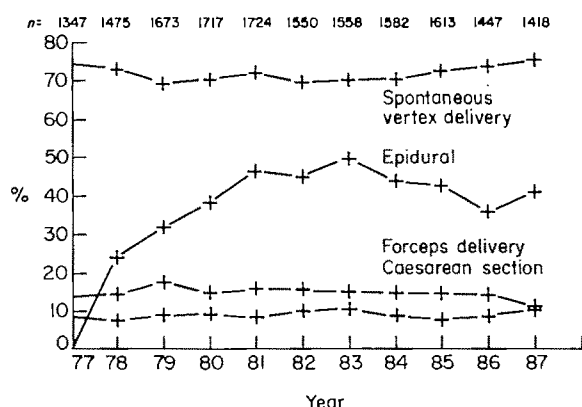


Fig. 1. Trends in increasing use of epidurals and decreasing instrumental delivery.

Table 1. The influence of obstetric policy on the use of forceps for delivery.

	Patients (primipara)	Mean length of second stage before (minutes)		Forceps rate
		Spontaneous delivery	Forceps delivery	
Obstetrician A	70	22.8	27.1	94%
Obstetrician H	71	59.4	75.6	20%

(Selected from Doughty, A. Obstetricians and the forceps rate. Personal communication.)

epidural analgesia. These patients were also prime candidates for forceps delivery. The free use of epidurals in normal obstetric patients subsequently reduced the proportion who needed the use of forceps. Other studies which compared epidural and nonepidural patients⁵⁻⁷ suffered from the fact that like was not compared with like.

Attempts to design a prospective trial of matched, contemporaneous deliveries today must be nigh impossible. Mothers have to be managed along traditional lines, when epidurals are not available, and even those with strong indications must be denied the benefits of the technique: but if epidurals *are* available, can it be right and humane to refuse the epidural when needed? Alternatively, can epidurals be given to mothers who have no need or desire for an epidural simply for the purposes of a trial? There is likely to be mismatching and imbalance in the epidural and nonepidural groups in any study.

Similarly, an examination of mothers delivered by forceps when epidurals are freely available⁸ would show that a very high proportion had epidurals during labour, since difficult cases needing forceps could benefit from the use of epidural. Indeed, the ultimate extreme would be to predict all mothers needing forceps and to provide them with epidural analgesia, so that 100% of forceps deliveries had had prior epidurals.

The study outlined in our paper described the effects of an abrupt impact of epidurals on a stable obstetric scene in the hope of having two groups of patients as nearly alike as possible. Consecutive years were deliberately studied during which the mothers delivered were similar in age, gravidity, social class *et cetera*. The population from which they were drawn was unchanged over the course of those 2 years. The pattern of deliveries was shown to have been steady for the 2 years preceding the advent of epidurals.

Doses of muscle relaxants

The choice of doses for vecuronium and alcuronium in the report by Kong and Cooper (*Anaesthesia* 1988; 43: 450-3) confused me.

Their purpose was to compare the ED₉₅ doses of these

Thus it was predicted that the obstetric need for instrumental intervention at delivery would be similar in the first year of epidural use, and it was postulated that any change in the pattern of deliveries might then be associated with the sudden use of epidurals.

A barely significant increase of forceps use was noted in the first year of epidural use, particularly in primiparae, despite the use of epidurals in 27% deliveries. The figure shows the trend in subsequent years of the increasing use of epidurals and the decreasing use of instrumental delivery. Epidurals are widely used in these patients, whatever else may be said, but the increase in the use of forceps can be described neither as inevitable nor sharp.⁹

It is not the use of epidurals that causes forceps to be used, but an obstetric decision. Doughty has provided evidence of the importance of this among a group of obstetricians with differing policies (Table 1). Progress in labour, whether in the first or second stage, is dependent upon efficient uterine contractions. As suggested in our paper, a revised management of the second stage of labour with regard to the use of increased oxytocin infusion and delay in pushing was adopted, and the forceps rate soon returned to previous normal levels.

Our initial small increase in use of forceps was as much due to obstetric expectation of the need for forceps with epidural use as to anything else.

The subtitle of our original paper *laying a bogey* was added in the hope that the spectre of inevitable, sharp increases in forceps use could be banished. Obviously, this is not to be and I dispute the final comment of Drs Hicks and Jenkins that the weight of evidence supports their view, and would regret very much if it were indeed shared by the majority of obstetric anaesthetists.

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P.W. BAILEY

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drugs with that of atracurium and to convince colleagues of the advantages of the newer muscle relaxants when used for laparoscopy. This aim was not achieved.

Their comparison of two other studies,^{1,2} whilst using

very different patient groups, revealed a similar $ED_{0.5}$ dose for pancuronium (62.2 and 64.4 $\mu\text{g/kg}$), but different $ED_{0.5}$ values for vecuronium (56.2 and 36.1 $\mu\text{g/kg}$). Kong and Cooper chose to use the smaller dose, yet their patients received 60 $\mu\text{g/kg}$ of vecuronium.

Krieg *et al.*¹ point out that a bolus dose of 36 $\mu\text{g/kg}$ vecuronium produced a neuromuscular block of only 79% in their study, but this is increased by the prior use of suxamethonium. This accounts for the different values between the two reports. Cumulative log-dose response curves may also produce lower values for the $ED_{0.5}$ dose when compared to the clinical use of a single bolus dose.

In my practice a dose of 80 $\mu\text{g/kg}$ vecuronium gives good, rapid intubation conditions, as suggested by Agoston *et al.*³ who found complete vocal cord relaxation in 90–100 seconds. Reversal of this dose after laparoscopy seems to cause no problem.

The use of smaller doses of relaxant probably depends upon a prolonged period of mask ventilation with a volatile agent to achieve tracheal intubation which may not be advisable in some patient groups (i.e. day cases).

Kong and Cooper reported a higher incidence of sore throat in the patients given vecuronium which may reflect the relatively small dose given. In comparison those given alcuronium (250 $\mu\text{g/kg}$) had a lower incidence of sore throat, but the most prolonged deficits in the measurements of postoperative muscle strength. This comparison may be unfair since the study referred to for the assessment of $ED_{0.5}$ doses¹ suggests a dose of only 140.8 $\mu\text{g/kg}$ for alcuronium, nearly half of that used.

However, the superiority of the newer muscle relaxants over alcuronium for short procedures such as laparoscopy must surely be intuitively correct.

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A reply

Thank you for the opportunity to reply to this letter. Our choice of dosage of alcuronium was based on the minimum which we had found clinically acceptable both for intubation and for postoperative recovery. We looked at the literature for equipotent dosage for atracurium and vecuronium and unfortunately we were unable to find a direct comparison of alcuronium, atracurium and vecuronium under identical conditions. This posed difficulties, as Dr Northwood points out, and involved us in the choice between 36 $\mu\text{g/kg}$ and 56 $\mu\text{g/kg}$ of vecuronium. Had we chosen a higher dose of vecuronium this might imply that a smaller dose of alcuronium would be equipotent to 60 $\mu\text{g/kg}$ of vecuronium. However, we have found the quality of intubating conditions unacceptable when we use less alcuronium. As shown the quality of intubating conditions were judged the same in the doses we used. Thus it does not seem that less complete muscle relaxation is the explanation for the higher incidence of sore throat.

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G.M. COOPER
K.L. KONG

Propofol in patients susceptible to malignant hyperpyrexia

A 46-year-old woman who weighed 62 kg presented for abdominal hysterectomy for fibroids. She was known to be susceptible to malignant hyperpyrexia (MH), following muscle biopsy at the Leeds MH Unit, and it was decided to undertake the procedure under spinal anaesthesia with sedation.

Premedication was with oral temazepam 20 mg, and spinal anaesthesia was obtained with 3 ml 0.5% bupivacaine in dextrose. Temperature was monitored from arrival in the anaesthetic room and once anaesthesia had reached the T_6 dermatome, an infusion of propofol was given. There was a brief episode of bradycardia which responded to intravenous glycopyrronium, but cardiovascular stability was otherwise good. There was no evidence of MH during the procedure and the patient was fully conscious within 5 minutes of the cessation of the propofol infusion. Her postoperative progress was uneventful and she was discharged home on the eighth postoperative day.

Propofol is not contraindicated in MH (in theory at least)^{1–3} and its uneventful use in the case described, who was known to be susceptible to MH, rather than just suspected to be susceptible, suggests that propofol is in fact safe to use in susceptible patients.

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Subarachnoid anaesthesia for elective Caesarean section

We read with interest the paper on this subject by Drs Michie, *et al.* (*Anaesthesia* 1988; **43**: 96–9). Our hospital in Zambia recently received a supply of 0.5% bupivacaine in 8% dextrose which has been used for the last 117 subarachnoid anaesthetics for Caesarean section. Lumbar punctures are carried out in the sitting position, which is preferred by our clinical officer anaesthetists, usually at L_{3-4} using 22-gauge reusable needles. The patient is

immediately placed supine with left lateral tilt after injection of bupivacaine.

Two millilitres of bupivacaine were injected in 77, and 2.5 ml in 40 patients; the amount used was at the anaesthetist's discretion. There were six failures in the 2-ml group, four of whom developed no block and two who had inadequate analgesia for surgery. Two of the complete failures were in the same patient on whom a spinal was attempted on 2

Table 1.

Maximum height of block	Number of patients	
	2 ml	2.5 ml
T ₂	3	5
T ₃₋₄	21	12
T ₅₋₆	25	11
T ₇₋₈	21	12
T ₉₋₁₀	1	0
Failures	6	0*
Totals	77	40

* $p = 0.076$ Fisher's exact test.

different days. Cerebrospinal fluid was obtained on both occasions but after injection of bupivacaine no sensory block developed.

Surgery usually started within 10 minutes of the injection and the pattern of cephalad spread is shown in Table 1. Most patients received a preload of about 1000 ml compound sodium lactate solution but 40 patients (34%) developed hypotension (<90 mmHg systolic by mercury sphygmomanometer) which was treated by intravenous ephedrine and fluids. The hypotension in two of these patients was very severe; blood pressure was immeasurable for a short period of time. This was probably associated with incorrect supine positioning of these patients. Both patients recovered rapidly following oxygenation, intravenous ephedrine and fluids. We have now adopted a policy of prophylactic intravenous ephedrine.

Epidural catheters are unavailable so we employ subarachnoid anaesthesia as our standard regional technique for Caesarean section and agree with Michie *et al.* that hyperbaric bupivacaine is a suitable agent. Our failure rate of 5% could be the result of the high proportion of blocks performed by trainees, but note that the overall failure rate in the paper by Michie *et al.* was of a similar magnitude, although their failures were only with hyperbaric cinchocaine. The sitting position for injection does not limit the spread of the block and we emphasise the importance

of an adequate preload, modification of the supine position, careful monitoring and the value of prophylactic ephedrine, particularly when monitoring facilities are frequently poor and the anaesthetist works alone.

One of us (K.R.N.) has seen two cases of uterine inversion at Caesarean section similar to those reported by Drs Emmott and Bennett.¹ Both cases had spinal anaesthesia and there was no noticeable decrease in blood pressure during or after the 10 minutes of inversion.

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Reference

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A reply

Thank you for the opportunity to reply. Two questions arise from the description of their technique for subarachnoid block with hyperbaric bupivacaine for Caesarean section. Firstly, with regard to needle size, was postural headache a significant problem? Secondly, the authors make the comment that 'the sitting position for injection does not limit the spread', yet in approximately one third of their patients maximum height was recorded at a level lower than the T₆ dermatome. How frequently, if at all, was supplemental analgesia required in this series of patients?

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A.R. MICHIE
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D.A. DUTTON
H.B. HOWIE

Bupivacaine and femoral nerve block

We have been following the correspondence on femoral blockade with interest.¹ We agree that this is a useful block but we also wish to add a note of caution about the choice of local anaesthetic.

We report a recent case of a London policeman who received 20 ml 0.25% bupivacaine under general anaesthesia for a right knee arthroscopy. A peripheral nerve stimulator was not used and we were using the 3-in-1 technique. His peri-operative progress was uneventful and he required no analgesics postoperatively since he had only very slight discomfort. Our main concern was his progressive inability to raise his leg because of an intense

motor quadriceps weakness which required an inconvenient overnight stay. The weakness persisted for 8 hours and confirms our suspicion that 0.25% bupivacaine is unsuitable for pain relief for day care knee surgery.

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Reference

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Asynchronous independent lung ventilation

Collapse or consolidation of one lung (partially or fully) is not an uncommon problem in the Intensive Care Unit. Resolution with bronchoscopy, changes in posture, intermittent positive pressure ventilation of the lungs (IPPV) and physiotherapy may eventually occur, but the period of poor gas exchange may be prolonged and cause concern. This problem recently arose in our ICU and was dealt with most effectively by asynchronous independent lung ventilation (AILV).

A 47-year-old man was admitted after a road traffic

accident which caused a right-sided chest injury. The clavicle and 3rd to 8th ribs were fractured: there was a large flail segment and the initial arterial blood gas analysis in Casualty is shown in Table 1(A).

Two right-sided chest drains were inserted and IPPV started with a Cape-Waine ventilator and blood gas analysis was satisfactory (B). His condition remained stable for 72 hours when airway pressure was noted to be increased and a chest X ray showed a total 'white-out' on the left. A diagnosis of total collapse of the left lung was

Table 1. Arterial blood gas results during IPPV and AILV.

Event	A	B	C	D	E		F	
pH	7.39	7.45	7.35	7.43	7.46		7.46	
Paco ₂ (kPa)	4.3	4.1	6.2	4.9	4.4		4.5	
Pao ₂ (kPa)	6.9	17.4	6.3	6.6	8.0		18.0	
Fio ₂	0.4	0.4	0.4	0.5	Right 0.46	Left 0.6	Right 0.4	Left 0.5
Peak airway pressure (kPa)		2.4	3.8	3.8	3.2	3.6	2.4	3.6
PEEP (kPa)		0.5	0.5	0.8	0.8	0.4	0.6	0.6
Tidal volume (ml)		800	900	1000	620	400	570	540
Rate (breaths/minute)		12	12	15	15	15	15	15

made and the blood gas analysis showed a marked deterioration (C).

The right lung showed patchy consolidation and was undoubtedly confused from the original injury so it was considered imperative to re-expand the left lung as quickly as possible before severe hypoxic damage occurred.

Aggressive physiotherapy and the removal of copious thick secretions through a flexible bronchoscope over the next 4 hours did not improve the X ray picture or the hypoxia (D). Therefore the patient was re-intubated with a left-sided Portex double lumen bronchial tube, size 5.5 mm internal diameter. Each stem was connected to a Cape-Waine ventilator set as shown in the Table and no attempt was made to synchronise them.

No cardiovascular changes could be detected; pulse and blood pressure were unchanged, but the blood gas analysis improved (E).

This improvement continued with a slowly increasing lung compliance and improvement in the blood gas values [those shown (F) in the Table were obtained after 17 hours of AILV].

The chest X ray showed full re-expansion of the left lung after 36 hours of AILV and a normal nasotracheal tube was inserted and conventional IPPV restored. A tracheostomy was later fashioned and after another week of IPPV a full recovery was made.

This patient's ventilatory crisis was precipitated by the relatively high compliance of the right lung because of a disrupted chest wall. Thus a smaller tidal volume was received by the left lung until collapse occurred, which left gas exchange dependent on the traumatised lung.

This situation may not have been reversed without AILV or at least not as quickly, and the manoeuvre also prevented any spill of secretions from one lung to the other. Suction of these proved no problem and was, if anything, more efficient.

The only problem encountered during AILV was with fixation of the double-lumen tube and prevention of kinking of the long extra-oral parts. This would not be a problem using a more modern ventilator incorporating a flexible arm for holding and positioning ventilator tubing.

AILV is very easy to institute and can be life saving, or help resolve a unilateral respiratory problem more quickly, by supplying volume and PEEP more efficiently to the affected lung, without compromise of the cardiovascular system. Its use should perhaps be considered more frequently than it is at present.

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D. NORTHWOOD

'Ethics' of difficult tracheal intubation

We read with interest the letter by Drs Callander and Thomas (*Anaesthesia* 1988; 43: 703-4) who are concerned about the ethical and practical problems they would face should a woman, who on previous occasions proved difficult to intubate, become pregnant.

The authors conclude that the optimum management for this patient would be to perform an elective tracheostomy, under local anaesthesia, during the 34th week of any pregnancy and to keep it patent until after the delivery.

The wisdom of this course of management must be questioned. Tracheostomy under local anaesthesia would be an unpleasant experience for the mother, and could be technically difficult for the surgeon, since during the 34th week of pregnancy the procedure should be performed in a wedged position in order to prevent venocaval occlusion. The longer term complications associated with tracheostomy, quite apart from the considerable discomfort and inconvenience suffered by the patient, cannot justify the procedure. In addition, if the justification of the tracheostomy is to minimise maternal risk and ensure a viable baby then surely the procedure should be performed at least during the 28th week of pregnancy since babies of this gestation now usually survive.

Rather than insisting on tracheal intubation, the authors should examine other possibilities to provide obstetric anaesthesia for this patient, in particular the use of spinal anaesthesia, which the authors dismiss in one sentence while failing to discuss other forms of regional anaesthesia

at all. Presumably they fear regional anaesthesia because in the event of a toxic reaction or total spinal anaesthesia, the patient would require tracheal intubation. These complications should not occur during a carefully conducted regional anaesthetic, but since they are more likely to be associated with the larger volumes of local anaesthetic used for epidural anaesthesia, spinal anaesthesia would therefore appear to be the anaesthetic technique of choice in this patient, and very few circumstances would preclude its use.

There would be two major dangers for the mother in the very unlikely event that an emergency general anaesthetic would be required, hypoxaemia and pulmonary aspiration of gastric contents. Provided the well documented precautions against acid aspiration are taken and assuming it was possible to maintain an airway during her previous anaesthetic, an anaesthetic technique which included the failed intubation drill advocated by Tunstall¹ could well be used in this patient. Whilst fully agreeing that forward planning is essential and that all steps must be taken to minimise known risks, it should be noted that while maternal deaths associated with anaesthesia have ranged from 31 (1955-57) to 50 (1967-69) to 22 (1979-81)² the recent improvement cannot necessarily be attributed to intubation of the trachea, at whatever cost.

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The letter on this subject from Drs Callander and Thomas (*Anaesthesia* 1988; 43: 703-4) was interesting reading. It appears from the description given by the authors that the technique of fiberoptic tracheal intubation was not used by them especially when they state that the intubation took one hour and fifty minutes. Fiberoptic tracheal intubation seems to be more appropriate under the circumstances described by the authors, and less time consuming.^{1,2} An elec-

tive tracheostomy performed at 34 weeks' gestation seems to be safest approach for her future pregnancy, but due consideration should be given to fiberoptic tracheal intubation. Further, a successful fiberoptic tracheal intubation would avoid a tracheostomy at every future pregnancy.

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Minitracheotomy in children

We were very interested to read the article by Allen and Hart (*Anaesthesia* 1988; 43: 760-1) and compliment them on their careful and responsible use of this technique. We agree that the principle of minitracheotomy is applicable to children, but the existing device is designed for the adult-sized trachea and has to be modified if it is used in children, as the authors point out. In particular, the scalpel blade may be too long for safety and the cannula may also be too long and possibly too wide to permit free breathing through the larynx. This is an important aspect of the technique.

We have used the minitracheotomy with appropriate modifications successfully in a boy aged 8.5 years, but we are loth to recommend its general use in children in the absence of a product designed specifically for this age group. We would be happy to see whether a suitable paediatric version could be produced if the authors feel that there is a significant need for minitracheotomy in children.

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H.R. MATTHEWS
R.B. HOPKINSON

A reply

Mr Matthews and Dr Hopkinson are entirely correct in stressing that the existing equipment for minitracheotomy is designed for adult use and requires modification if it is to be used in a child. The potential for its use in children who might benefit from minitracheotomy to justify a specially designed version, is difficult to estimate. The number involved is unlikely to be large. Brain damage with its associated neurological defects would be the major source of cases with sputum retention. Our hospital covers a population of approximately 1.2 million for this category of patients. No minitracheotomy, and no tracheostomy for sputum retention alone, has been carried out here in a child during the past 2 years.

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S.M. HART
P.W. ALLEN

Blind nasal intubation and (or) fiberoptic guided intubation?

In their description of a method of teaching guided fiberoptic nasotracheal intubation Coe, King and Towey (*Anaesthesia* 1988; 43: 410-3) omit to mention informed consent, selection, sterilisation of the bronchoscope,¹ and the duration of anaesthesia before the fibrescope is introduced. They argue that fiberoptic nasal intubation (FNI) has a higher success rate, and can be expected to be less traumatic, than blind nasal intubation (BNI) and that 'red-out' is related to reduction in the supraglottic space from lessened tongue tonus.

FNI and BNI are both valuable means of intubation. It is surely counterproductive to claim superiority for one over the other on the basis of quoted series which report small numbers and different intubations, intubators and anaesthetic methods. Should they not be seen as supplementing or complementing, rather than competing with or replacing, each other? The interests of patient safety would be best served by all anaesthetists becoming skilled in both. Blind nasal intubation has been used successfully in all except one of the cases of ankylosis or gross trismus who have presented to a maxillofacial unit over a 12-year period.² The exception was an adult male, with no jaw opening, for left coronoidectomy in whom it proved impossible to pass even 5.0 mm ID tubes through the nose and became necessary to intubate orally, through a gap formed by the absence of several upper incisor teeth, blindly. Blind nasal intubation was also always successful in 1000 consecutive unselected patients, under apnoeic

general anaesthesia. There were 42 patients with ankylosis or gross trismus, and 12 with wired jaws. The age range was 3 months to 79 years and the body weight was between 6.5 kg and 108.9 kg. On 41 occasions (range 1-9 in each 100 cases) an ordinary malleable metal stylet was used to achieve an appropriate curve of the tracheal tube. A 7-year-old haemophilic was orally intubated, to avoid epistaxis risk, and two adults who required awake local anaesthesia BNI (one with a severe Ludwig's angina and one with a C6-7 subluxation cervical spine injury) were excluded.

Ovassapian *et al.*³ excluded 10 failures to pass the tube or fibrescope through narrow nasal passages from the calculation of their 98.8% FNI success rate. The tracheal tube still has to be introduced, through the nose and larynx with FNI, before or after the insertion of the fibrescope and vision plays little part in this. In BNI the eyes observe the anterior neck, and the very sensitively innervated pulps of the thumb and index finger manipulate the tube to locate the glottic hole. The force is comparable to threading the eye of a needle or testing skin sensation with a Frey's hair. Coe, King and Towey report a 22% incidence of epistaxis despite using the more patent nostril and applying 5% cocaine to the nasal mucosa. My incidence of 14% epistaxis over 900 BNI cases (range 8-21 in each 100 cases) was when trainees inserted the tubes; there was no nasal vasoconstrictor and patency was not assessed.

Intubation trauma, especially epistaxis, seems to depend on the intubator and the patient.

The epiglottis can remain in contact with the posterior pharyngeal wall, in spite of optimal head and neck position, and thereby interfere with the passage of a tube or a fibroscope. Positioning can, therefore, be as significant in FNI as in BNI. The tube can be rotated 180 degrees in BNI to run the distal end down the posterior pharyngeal wall to pass the epiglottis and then 180° reversed or 360° completed, to enter the glottis. In FNI red is seen despite manoeuvring the fibroscope in all directions, though the instrument can be seen distorting (and possibly transilluminating) the anterior neck.

Ovassapian *et al.*^{3,4} comment on difficulties produced by the decreased space between the edge of the epiglottis and the posterior pharyngeal wall. Some FNI exponents pull the tongue anteriorly⁵ but equally the tube can be introduced first to hold the tongue and epiglottis forward and the fibroscope inserted through the tube to visualise the glottis. It is worth trying positions other than the classical one of 'sniffing the morning air', flexion or extension of the neck together with extension of the head, to reveal the epiglottis after which the glottis can usually be located. As Coe, King and Towey used an oropharyngeal airway and firm chin elevation it seems less likely that the 'red-outs' they experienced derived solely from reduction of tongue tone.

BNI and FNI each have advantages and disadvantages. In a particular situation one may possibly be easier, quicker or preferable. BNI is immediately and universally available. Training and experience in the signs used in BNI can assist in the prevention of oesophageal intubation. It can also be versatile; I have used BNI on a prone positioned patient, several in the lateral position and several with cricoid pressure applied. Instruction certainly needs to be given to trainees on the care and handling of the fibroscope but they should themselves be capable of gaining plentiful experience in a wide range of patients by means of its insertion and use to visualise the glottis. Is so much more gained by introduction of the tubes also unless it is actually necessary as in a difficult intubation? The clinical material described by Coe, King and Towey is ideal and valuable for the teaching and practice of BNI and, when viewed in the context of every learner becoming a teacher, could and should be used as such.

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A reply

Thank you for the opportunity to reply to Dr Williamson. The patients selected were 50 consecutive patients within the age and ASA gradings stated in the article, which accounts for the normal and difficult patients encountered. We regard the disinfection of fibroscopes to be mandatory and have always cleaned and disinfected them before use and between patients. The scope remains immersed in a disinfection tray until the last possible moment when it is rinsed in sterile water and prepared with a sterile tracheal tube by the endoscopist. We found the advice on duration of scope immersion to vary from hospital to hospital, and welcome the recent article which discusses the problems of fibroscope sterilisation.¹

We agree that both blind nasal and fiberoptic intubation are valuable and we practise both techniques. Dr Williamson is obviously an expert at blind nasal intubation as his series of patients demonstrates. We however find it difficult on normal patients to achieve the success rate of 85.6-97.1% that has been suggested for using BNI during difficult intubations.²⁻⁵ We did however achieve a higher success rate (100%) on the group of 50 consecutive patients using FNI.

Difficulty with the passage of tracheal tubes through the nose is a problem with both methods but the fiberoptic technique has the advantage that it is possible to find a pathway through the nose under direct vision. Beyond this stage, intubation of the glottis under direct vision should be less traumatic in most people's hands than a blind technique. The techniques have features in common; we teach both, but consider that the fiberoptic one takes blind intubation a stage further, it allows direct vision to be used instead of less reliable sensations of touch and hearing.

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Excel 410 anaesthetic machine

The evaluation of this machine by Drs Emmett, Clutton-Brock, and Professor Hutton (*Anaesthesia* 1988; **43**: 581-3) was interesting. May I emphasise a further point of possible confusion with this machine not mentioned in their paper?

The authors state the gas valves to be in the normal place. That is so, but they are not in the normal order. As can be seen in Figure 2 of their article the nitrous oxide control valve has been moved from its traditional position on the far right of the Rotameter block to immediately

17/11/88

adjacent to the oxygen control valve, that is second in from the left. More than one anaesthetist (myself included) commenced an oxygen and carbon dioxide anaesthetic using the traditional far right and far left control knobs during the assessment of a three-gas Excel 410 loaned to us.

This unfortunate repositioning of the controls reinforces the point made in the paper that special familiarisation programmes must be undertaken on the introduction of this machine, or when new anaesthetists are introduced to it.

Another manufacturer (M.&I.E.) has overcome the engineering problem associated with the antihypoxia link and has the flowmeters in the traditional positions, in their new machines.

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J.R.A. MOON

Elbow support in a dental unit for the disabled

Use of a dental chair in our unit for the treatment of physically or mentally handicapped patients presents problems, one of which is inadequate arm support when horizontal. Conventional operating theatre rests do not fit a curved surface. We have found that a length of ticking can be placed without difficulty when the chair is upright and then attached in position around the elbows when level (Fig. 1), giving support and complete protection to the ulnar nerves. Velcro straps also hold the breathing system tubes and monitoring lines. Alternative sizes suit all patients.

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Fig. 1. Elbow support in use.

'Cockpit' drill

The hazard reported by R. J. Lenoir and W. R. Easy (*Anaesthesia* 1988; **43**: 892-3) was interesting. A colleague and myself recently reported on the possibility of this problem occurring and included an assessment of the substantial leaks involved.¹ The leaks were found to exist for air, cyclopropane and carbon dioxide systems in a sample of anaesthetic machines from several manufacturers. The degree of leak was found to vary with the amount of backpressure on the system and so is largest where minute volume divider ventilators are in use. This subsequent report demonstrates the reality of this problem and raises several points that are worthy of comment.

The importance of monitoring the F_{IO_2} in the anaesthetic system is again demonstrated. The value of this method of monitoring is not disputed and it is included in the recently published guidelines on patient monitoring.² The ability of standard cockpit drills to pick up serious faults, particularly leaks, in anaesthetic equipment has repeatedly been thrown into doubt.^{3,4} Unfortunately this has encouraged some anaesthetists to perform perfunctory tests or even to abandon the drill. Despite this, it is well established that it is our responsibility to check all anaesthetic equipment before starting a list.⁵ Simple modifications overcome the deficiencies in the present cockpit drill and I believe would have picked up the faults quoted. The cockpit drill should include an initial inspection to ensure that all yokes have either a cylinder or a yolk plug fitted. After the single hose test⁶ which requires that all Rotameters should be switched on (including for gases not connected), the operator must

ensure that they are all turned to the off position. The inadequacy of assessing leaks by occlusion of the common gas outlet and watching for 'bobbin bounce' has again been shown by this report. A final refinement to the drill should be the inclusion of the technique described by Page⁷ to assess gas leakage from the machine. The machine common gas outlet is connected to a pressure gauge (such as blood pressure or a tourniquet gauge adapted with 22-mm female connector), the oxygen Rotameter is slowly opened and adjusted to maintain a pressure of 16 kPa (120 mmHg) in the backbar. The oxygen flow is an indication of the leakage and more than 200-300 ml/minute is considered unacceptable. This technique utilises equipment readily available in every theatre complex and adds little time to the performance of a cockpit drill.

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Severe coagulopathy in a Jehovah's Witness

We read with interest the case report of severe coagulopathy in a Jehovah's Witness (*Anaesthesia* 1988; **43**: 391-3). We are, however, not entirely satisfied that the hydroxyethyl starch used to maintain blood volume was the cause of the acquired haemostatic deficiency.

The authors mention the maintenance of 'planned profound hypotension' as part of the anaesthetic technique during the surgical procedure, but do not give details of the method by which this was achieved, or the degree of hypotension produced. These details may be relevant. It has been shown¹ that hypotension and blood volume dilution can lead to development of a coagulopathy the severity of which depends on the degree and duration of hypotension. The combination of blood loss, haemodilution and pharmacologically induced hypotension may have produced a reduction in organ perfusion with haem-

atological consequences similar to those anticipated in haemorrhagic shock. Hydroxyethyl starch, with its recognised ability to cause haemostatic defects, may have contributed to the coagulopathy, but it cannot be concluded that it was the sole cause.

Mr Edgar is fortunate to have such thorough colleagues.

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D. COATES

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Sick sinus syndrome manifest after spinal anaesthesia

It was interesting to read the case report of Drs Underwood and Glynn (*Anaesthesia* 1988; **43**: 307-9).

Recently, we witnessed a similar episode after a spinal anaesthetic. The case involved an 83-year-old deaf and dumb woman who had a subendocardial anterolateral myocardial infarct in 1985 with no subsequent history of angina. She was not on any regular medication. She was undergoing a vaginal hysterectomy and anterior vaginal repair for treatment of prolapse.

The pre-operative 12-lead ECG showed sinus rhythm with occasional atrial ectopic beats. She was preloaded with 500 ml polygeline. A spinal was performed using a 25-gauge needle with the patient in the sitting position. Two millilitres of 0.5% heavy bupivacaine were injected. She was given 2.5 mg midazolam intravenously during the

operation. She was noted to be in sinus rhythm at a rate of 35 beats/minute, associated with a systolic blood pressure of 90 mmHg, in the recovery room. The patient was asymptomatic. The bradycardia responded to 0.3 mg intravenous glycopyrronium.

Several days later, the patient complained of atypical right-sided chest pain which was of short duration and settled spontaneously. An ECG performed at the time showed a sinus arrhythmia with occasional atrial ectopics.

This may be another example of sick sinus syndrome brought to light by a spinal anaesthetic.

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C.S. CORR
D.A. THOMAS

Broken laryngoscope

We would like to report another possible cause for a difficult intubation. The laryngoscope broke during laryngoscopy on a 59-year-old male for coronary artery bypass. The laryngoscope had been checked beforehand

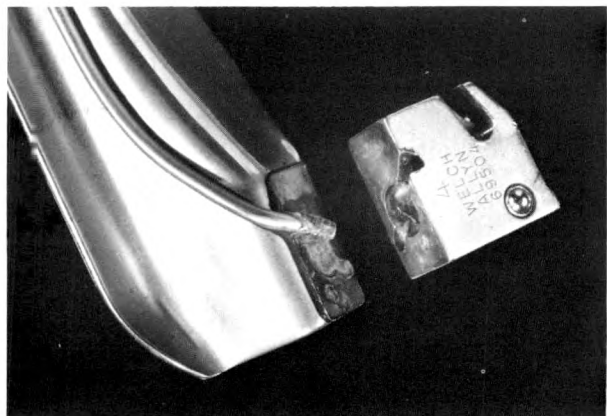


Fig. 1.

and had functioned normally. Extreme care and minimal force was being employed during the procedure because the patient had loose and missing teeth. The blade and the insert into the handle separated when the mandible was lifted with the laryngoscope. The break was along the line of solder between the blade and the key insert into the yoke of the laryngoscope handle. The problem was further compounded because the broken piece could not be removed from the handle and a second blade could not be inserted. Using a second laryngoscope, intubation was successfully achieved without harm to the patient.

Failure of the light bulb on a laryngoscope is not uncommon, but it is easily remedied either with a new bulb, blade or handle. We can find no reports of this type of failure. We would recommend that, in the future, not only the electrical integrity of the laryngoscope be checked but also that the blade and handle be stress tested as well.

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Bone cement

Insertion of bone cement into the femoral shaft during total hip replacement often produces hypotension and hypoxaemia. Other reported adverse reactions include cardiac arrhythmias, myocardial infarction, cardiac arrest, pulmonary embolism and cerebrovascular accident. Bronchospasm should be added to this list after the occurrence of this complication in an obese 79-year-old-woman with a long history of asthma, who had a replacement arthroplasty of her right hip as an elective procedure. Her asthma was treated for 4 days before surgery with nebulised salbutamol and oral prednisolone 10 mg, four times a day, which caused improvement in her condition. She was premedicated with temazepam 20 mg orally and anaesthesia was induced with propofol 150 mg and fentanyl 350 µg. Vecuronium 8 mg was given and her trachea intubated with a short tracheal tube and her lungs ventilated with 66% nitrous oxide, 33% oxygen and 1% enflurane. Surgery progressed well, the acetabular component was cemented in place without incident until insertion of the femoral shaft cement. The peak inflation pressure increased from 2.4 to 4.5 kPa within seconds and marked bilateral wheeze was evident on auscultation of her chest. She remained well perfused with no change in pulse rate or blood pressure; there was no oedema. The bronchospasm responded to intravenous aminophylline 250 mg given over 5 minutes followed by an infusion of 40 mg/hour. Her subsequent recovery was uneventful.

The bone cement used was Palacos R with Gentamicin (Kirby-Warrick) which is supplied as a powder and liquid which, when mixed, form a paste which is injected between

bone and prosthesis and hardens *in situ*. The powder contains mainly acrylic polymer with zirconium dioxide to confer radio-opacity, traces of benzoyl peroxide which initiates hardening, chlorophyll for colour and 500 mg of gentamicin to discourage infection. The liquid component is mainly methyl methacrylate monomer stabilised with hydroquinone and mixed with the solvent dimethylparatoluidine. The benzoyl peroxide dissolves in the solvent upon mixing the powder and liquid and reacts with the monomer, probably generating extremely reactive epoxides and free radicals and initiating the extremely exothermic polymerisation reaction. The cement heats up to around 90°C so the reaction proceeds rapidly and is almost complete in 15 minutes. The introduction of cement into the shaft under pressure causes micro-embolisation of air and fat, and the blood which drains the femoral shaft is heated sufficiently to denature its proteins and release intracellular components into the circulation. Free methyl methacrylate monomer, which is corrosive to skin, plastic and rubber is released in sufficient quantities for its distinctive odour to be obvious in the expired gases of the patient. Perhaps the rational approach to cemented arthroplasty in view of all this is to expect complications, be humbly grateful should they fail to occur (as is usually the case) and to follow the development of noncemented prostheses with interest.

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J.M. SLADE

Book reviews

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Anaesthesia for thoracic surgery

J.L. BENUMOF. Pp. xii + 521. W.B. Saunders, 1987. £50.00.

Recent years have seen the publication of a number of important texts on thoracic anaesthesia, from both sides of the Atlantic. This upsurge in interest is perhaps not before time, and surely represents the emergence of thoracic anaesthesia from the shadow of cardiac anaesthesia, which has understandably been the dominant area of cardiothoracic anaesthesia for the last 20 years. This latest textbook is a single author text, written by one of the most prominent anaesthetists involved in this specialty in North America.

The book is nearly 500 pages long, and is divided into five sections. These are logical in sequence; thus 'basic considerations' is followed by 'pre-operative considerations', 'intra-operative considerations for all thoracic surgery', 'intra-operative considerations for special thoracic surgery' and 'postoperative considerations'. These five sections are further subdivided into a total of 20 chapters, each of which is prefaced by a list of contents. One feature of the book is the many, large, clear diagrams throughout the text, some of which have been redrawn to ensure continuity of style. Each chapter is fully referenced with recent publications (up to mid-1986); although American work naturally predominates, British work is also extensively cited. It is also good to see due recognition given to the work of Magill and other pioneering British anaesthetists in the history section. There is a comprehensive index which is some 50 pages long.

Overall, this is a first class book and by far the most comprehensive current textbook on thoracic anaesthesia. One could recommend it to trainee anaesthetists for the first section alone, which is excellent. Subsequent sections are also good, although the obvious differences between UK and American practice at times stand out. Specimen anaesthetic techniques are given even for the most recent developments (e.g. Nd YAG laser) and although perhaps not this reviewer's choice they are always logical and well argued.

Without doubt this is a book for every anaesthetic department library, and for every specialist in thoracic anaesthesia. Trainees and others who have an interest in thoracic anaesthesia may also wish to purchase their own copy, and I believe they will not be disappointed.

R.O. FENECK

Anaesthesia for thoracic procedures

Edited by B.E. MARSHALL, D.E. LONGNECKER AND H. B. FAIRLEY. Pp. 632. Blackwell Scientific, 1988. £72.20.

It gave me considerable pleasure to be asked to review this book but this was tempered by the fact that it has 632 pages. The book covers everything from the sternum to the vertebral column and from the larynx to the diaphragm. The chapters are set out well, have summaries at the end and are well referenced.

The first 12 chapters contain some anatomical considerations and a great deal of well presented medicine and physiology. The chapters dealing with pulmonary ventilation, blood flow and oxygenation are particularly good. The section on pharmacology, though well written, appears to be a short version of a standard pharmacological textbook. The chapter on lung evaluation is disappointing for anaesthetists since it does not appear to discuss the relevance of blood gases. One of the more interesting chapters was that dealing with Psychologic Preparation written by a doctor who has a professorship in both Anesthesiology and Psychiatry (one wonders which came first!). This chapter should be compulsory reading for all anaesthetists and surgeons. The middle section of this book, dealing with assessments of coincident medical conditions, surgical approaches and the development of an anaesthetic plan, seem to be somewhat unwarranted: there is much medicine, but chapters seven and eight would perhaps be more suited to a medical than to an anaesthetic text.

The chapters on the practical management of what is traditional thoracic anaesthesia are excellent though somewhat long, as a result partly of some duplication of physiology. The book (cardiac anaesthesia is omitted), discusses heart-lung transplantation. This is a concise chapter, makes interesting reading, and contains an excellent section on management including immunotherapy. The book ends with three chapters on postoperative management and complications, including acute respiratory failure of the thoracic patient. The treatment of post thoracotomy pain was insufficient and these chapters could have been condensed.

What do I think of this book having read all 22 chapters? It is too long and contains a few chapters which could easily be omitted. The strengths of the book, however, are the chapters on physiology and practical management of thoracic procedures. The editors in their

preface ask the reader, having read the book, to think, test and adapt their practice; they have certainly achieved their aim with most but not with all chapters. In conclusion, this book is probably not for personal purchase but it should be used for reference and found in all major libraries.

R.S. VAUGHAN

Guide to Immediate anaesthetic reactions

Edited by J. WATKINS AND C.J. LEVY. Pp. viii + 128. Butterworths, 1988. £9.95.

This short book ('designed to fit the pocket rather than the bookshelf') is a practical guide to anaesthetists, surgeons, allergists and other interested clinicians, to assist them with the understanding, diagnosis, and management of life-threatening, immediate anaesthetic reactions. It contains contributions by the two editors, particularly the first one, and by five other authors. The major part deals with the so-called anaphylactoid reactions, with some coverage of reactions related to defects in enzyme functions. The book begins with some of the basic immunological principles which pave the way to the discussion of the immunological mechanisms that underly some of the reactions. Proposed mechanisms for anaphylactic-like, apparently nonimmunologically mediated reactions are discussed in different places. A separate chapter is devoted to reactions related to enzyme abnormalities and metabolic defects, including malignant hyperpyrexia, abnormalities in plasma cholinesterase and suxamethonium apnoea. The book also includes a survey of adverse anaesthetic reactions and their practical management, including various laboratory investigations, treatment of anaphylactoid reactions and other aspects of the management of immediate reactions. The six chapters are complemented by five appendices which include further details: case presentations (eight examples), comprehensive treatment of anaphylactoid reactions, *in vivo* and *in vitro* tests, prophylactic procedures and reporting (to the Committee on Safety of Medicines and specialised information and laboratory centres) and registration such as the Medic-Alert emblem system. The book contains some useful illustrations.

The importance of adverse reactions to the multitude of drugs used in anaesthetic practice has attracted considerable attention in recent years since some of them are potentially fatal. Advances have been made in unravelling certain reactions in terms both of their mechanisms and their investigation, and the book offers some help to the anaesthetist to grasp these developments. However, to achieve this objective (naturally at the expense of space and departure from simplicity) certain points should receive attention. Firstly, definitions should be precise, clear and consistent, e.g. anaphylactoid, histaminoid, pseudo-allergic, idiosyncratic; otherwise confusion will result. Second, mechanisms (chapters two and three and appendix C), are important: certain parts are oversimplified and further detail is necessary for clearer understanding, particularly host factors, paradoxical role of immunosuppression in predisposing to allergy, nature of the drug both structurally and pharmacologically and requirements for the release of histamine and other mediators, drug-specific IgE antibodies and their significance (mentioned in passing in relation to neuromuscular blockers, and generally assumed to be of little importance), role of immune complexes, the so-called aggregate anaphylaxis and particularly the effects of anaphylatoxins, explanation of the term 'chemotoxic', why patients with 'atopy' and high IgE are at a greater risk even of reactions that are apparently nonimmunologically mediated, and how can those with the

other extreme (low IgE) also be at risk (explanation on page 64 is vague). Thirdly, tests: skin tests and their value in reactions to different groups of drugs and individual members of the same group or subgroup, for example testing with suxamethonium, tubocurarine or atracurium. One noticeable omission is that of the *in vitro* release of histamine from blood leucocytes, which is a reliable correlate of immediate reactions, whether truly anaphylactic (IgE-mediated) or apparently not (when such antibodies cannot be detected and history of prior exposure is lacking). The test cannot be simply equated with the basophil degranulation test since what matters is the release of mediators such as histamine rather than the morphological changes which may accompany the release process. Fourthly, the examples given (eight cases, appendix A) are interesting and should have been followed by comments on diagnostic clues. Finally, there are too few references; more are needed if some of the controversial issues are to be followed.

Despite the above points, the anaesthetist will find this book (which is easy to read) of value in understanding and managing these reactions.

E.S.K. ASSEM

Disorders of ventilation

J. SHNEERSON. Pp ix + 389. Blackwell Scientific, 1988. £55.00.

This book describes and examines the causes of ventilatory failure and in doing so fills a definite gap in both the anaesthetic and intensive care literature. It is written in an authoritative manner by a respiratory physician who is involved in the management of a chronic respiratory unit and obviously has extensive experience in this field. This results in a refreshingly different approach to a subject which is usually either overlooked or discussed in a perfunctory fashion.

The title *Disorders of ventilation* describes well the orientation of the book, which is towards failure of the 'respiratory' pump and does not encroach, at all, on lung pathophysiology.

The scientific basis of the subject, that is the control of ventilation and the structural components of the respiratory 'pump' are discussed in a concise and clear manner, as are general topics such as the range and mechanisms of abnormal breathing patterns, sleep apnoeas and relevant aspects of history and examination.

However, it is the section relating to individual disorders of ventilation which is outstanding as a mine of useful and interesting information for anaesthetist and intensivist alike. This covers many of the disorders which directly affect ventilation. It is done in a structured fashion working from central control through to peripheral components. A large number of varied topics such as Parkinson's disease, central alveolar hypoventilation, spinal cord injury and diseases of respiratory muscles are covered in detail. The chapter concerned with ventilatory problems due to chest wall and spinal abnormalities, which is generally a neglected area, is dealt with in a particularly thorough manner and is excellent reading.

The final section is in effect a thorough dissertation of the various forms of negative and positive pressure devices which can be used for disorders of ventilation and covers all their potential benefits and problems. Included is a list of available devices, where they can be acquired and the cost. Newer innovations such as nasal CPAP are also discussed and the whole topic of electrophrenic respiration is evaluated in detail. The central theme of this section of

the book is the management of chronic respiratory failure requiring ventilation and the options available.

There are only a few chronic ventilatory units in this country and as a consequence only a small number of trainees in either anaesthesia or intensive care have the benefit of experience in this field. However all intensivists and most anaesthetists will deal with patients who may require this type of management approach and this book provides a useful and instructive reference text.

Aimed at specialists and costing £55.00 it is good value for money as a specialist text. The book is well written and easy to read. The references are comprehensive. There is generous use of flow diagrams, the majority of which are extremely clear and therefore simple to follow. It is probably not a first line book for anaesthetic trainees, but it is certainly a reference book which, ideally, should be available to them. As previously mentioned it is a somewhat neglected area both in the ITU literature and in ITU training and consequently this book would be a useful asset to any ITU.

N. SONI

Intravenous anaesthesia

J.W. DUNDEE AND F.M. WYANT. Pp. ix + 358. Churchill Livingstone, 1988. £50.

In their preface, the authors state that it is 11 years since the publication of the first edition of this book although since the first was published in 1974, I would think it more like 14! Nevertheless, much has happened in the field of intravenous anaesthesia over the past decade which has had considerable influence on the second edition of this excellent textbook. In a review of the first edition the author states that Althesin has been given a restrained welcome which is appropriate to a new drug which will soon be gaining significant acceptance! It is strange to think that this drug has now been withdrawn along with a number of others. To their credit, the authors have not dwelt upon drugs no longer available, apart from sensibly putting them in a chapter at the end of the book, entitled 'Drugs of Historical Interest'.

Unlike many second editions, the book has in fact been extensively re-written, which is appropriate to a subject that has advanced so far so recently. A significant chapter towards the beginning of the book on the pharmacokinetics of intravenous anaesthetics is an extremely welcome and well written addition in an area which is becoming increasingly important, particularly with infusion anaesthesia.

Approximately one-third of the detailed discussion of individual agents available is devoted to barbiturates, as was indeed so in the first edition. This is again appropriate since these drugs at present still form the backbone of our intravenous induction agents. Each chapter is comprehensively indexed and referenced and, in addition to the pharmacodynamics and pharmacokinetics of barbiturates, there is a specific chapter devoted to their mode of action on the central nervous system, which makes interesting reading, particularly for examination candidates.

It is from here on in the book that the most noticeable differences occur. Chapters on the 'Eugenol derivatives', such as propanidid and the steroids are now omitted to be replaced by individual chapters on 'Ketamine', 'Etomidate' and 'Propofol'. In the case of this latter drug I feel that the publication of the book at this time is unfortunately slightly ill-timed. In the last 18 months, propofol has become a significant part of almost every anaesthetists induction regimen, certainly in the United Kingdom and yet, because of the inevitable production delays with a

book of this kind, the inclusion of propofol is only considered as that of a very new drug. This is also true of a number of areas of the book, where the most recent reference to anything that I could find was 1986, more than 2 years prior to its publication. In a rapidly advancing science of something such as intravenous anaesthesia, it is a pity that such delays occur.

Other significant and important additions to the book include excellent chapters on 'Opioids in intravenous anaesthesia', 'Hypersensitivity to intravenous anaesthetics' and 'The prevention and treatment of brain ischaemia'. The inclusion of such chapters has made this an exceedingly comprehensive textbook of intravenous anaesthetics but it was slightly disappointing to see that a chapter entitled 'Infusion anaesthesia' only dealt really with the intravenous induction agents and analgesia. If one is to talk truly about intravenous infusion anaesthesia, then surely some mention should be made of the newer short acting neuromuscular blocking agents such as atracurium and vecuronium and their use in this technique, since muscle relaxation forms a very definite part of the triad of anaesthesia, which must be provided in any comprehensive anaesthetic technique.

Both authors have had considerable experience in many aspects of the research and development of intravenous anaesthetics; both barbiturates and some of the newer agents. They have produced, with the aid of three co-authors, all of whom have worked closely with them, a comprehensive book which not only contains a vast amount of information but also complete lists of all the appropriate references. While I think that such a book is considerably more detailed than is necessary for trainee anaesthetists at the time of their examinations, I believe it is essential for any anaesthetic library and, indeed, for any more senior anaesthetist intending to use intravenous anaesthetic agents in their wider context. Although £50 may seem, at first glance, a significant expense for such a book, the quality of the paper and printing, quite apart from the value of the text, do more than justify this price.

P.J. SIMPSON

A bibliography of references to anaesthesia in Australian medical journals 1846-1962

G.C. WILSON, Faculty of Anaesthetists, Royal Australasian College of Surgeons in Melbourne, Victoria, Australia. 60\$A plus postage.

Regular readers of *Anaesthesia* are unlikely to wish to read this comprehensive bibliographic index. There are 409 pages of references in various appropriate sections and listed in date order. The publication, supported by the Faculty of Anaesthetists of the Royal Australasian College of Surgeons, represents a standard of scholarship which few even attempt, fewer equal, and none excel. The book itself will rest in the library of the Association of Anaesthetists of Great Britain and Ireland for consultation.

The Editor

Books received

We thank the publishers for the following books, some of which may be reviewed in future issues of the journal.

Annual review of pulmonary and critical care medicine

Edited by R.A. MATTHAY, M.A. MATHAY AND H.P. WIEDEMANN. Pp. v + 201. Blackwell Scientific, 1988. £39.50.

Anaesthetic literature

This section of *Anaesthetic literature* contains references taken from *Current Contents—Life Sciences* for October 1988. The Journals which may be consulted when *Anaesthetic literature* is compiled are those listed in *Current Contents—Life Sciences*, published by the Institute of Scientific Information, Philadelphia, Pennsylvania, USA.

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The collator of this section is Dr L. Kaufman, MD, FFARCS, Anaesthetic Office, The Rayne Institute, University College, University Street, London WC1E 6JJ. Dr Kaufman is prepared to provide on request, and at a modest charge, a new additional service to our readers. References from January 1984 have been entered on data base. The data are held on Dbase II, cpm 86 and on Dbase III, MsDos and are available on disc, together with a program providing search facilities. Enquiries direct to Dr Kaufman at the above address please.

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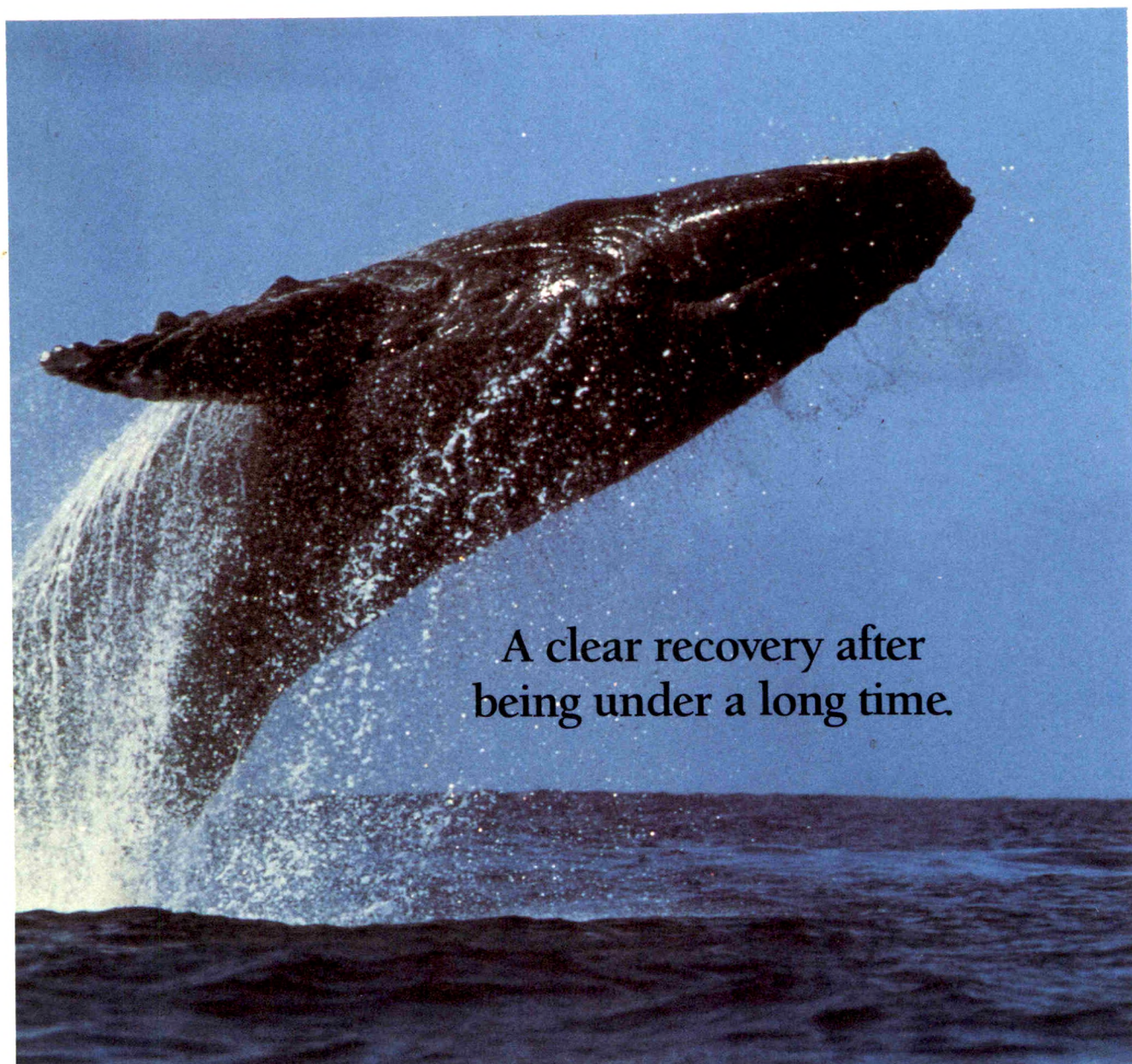
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- facilitate the movement of anaesthesiologists in Europe, especially in the countries of the EEC.

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in Strasbourg, Oslo, Barcelona, Uppsala, Lund and Berne.

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**The Examination Secretary, European Academy of Anaesthesiology,
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Editorial

Anaesthesia and intensive care

It has recently been announced that the Association of Anaesthetists of Great Britain and Ireland and the Faculty (College) of Anaesthetists have combined to fund a Senior Lectureship in Intensive Therapy. It is intended that this post will be held in a busy intensive therapy unit which is associated with a University Department of Anaesthesia. In the first instance it will be for 5 years but it is hoped that sufficient funds will ultimately be forthcoming to make this a recurring appointment provided that it proves to be a success. This is a unique event, being the first time that the two bodies have united to create a senior academic post and it deserves success.

The avowed intentions of this creation are several. In the first instance it is to make it possible for an appropriately qualified anaesthetist with a major interest in intensive therapy to perform fundamental research in a proper environment. The research carried out by anaesthetists associated with intensive therapy units at present falls into three main categories: these are, clinical case studies combined with a review of the literature; a wide variety of drug and equipment trials; epidemiological reviews. All of this type of work is admirable and much of it is very valuable. However, if the care of patients is to be improved many basic problems must be clarified. These can only be investigated with a fully staffed research department which has all of the technical backup and multidisciplinary input which a university department within a medical school environment can provide.

In intensive therapy, as in many other branches of medicine, we have reached the point at which we know which questions to ask, but have little idea how to obtain the answers and many of those we have are tantalisingly ambiguous.

An example of the type of research which is required is, to determine and to understand the fundamental tissue response to hypoxia, ischaemia and sepsis. This requires the combined efforts of a research clinician, a biochemist, a statistician and others to be performed adequately. This would of necessity be a long term programme but it is only through its pursuance that any of the questions which are now being asked can be answered.

There is a dearth of this type of research and little of it is credited to anaesthetists. In the United Kingdom¹ 85% of intensive therapy units, which have a recognised consultant in charge, are run by anaesthetists but because of the nature of their clinical responsibilities

and the difficulty of obtaining major research grants few of them are able to engage in long term prospective investigations.

Anaesthetists should be ideally placed to lead and take part in the type of fundamental research described above because of their basic interest in physiology and pharmacology and the requirements of the F.C.Anaes. With some laudable exceptions British anaesthetists are not well represented in the journals which publish intensive therapy related investigations; for example, this year, at the Fourth European Congress of Intensive Care Medicine in Italy only five papers out of 212 listed had originated in the United Kingdom.

Other benefits should accrue from the establishment of a Senior Lectureship. There is general dissatisfaction with the postgraduate training in intensive therapy skills. A department which has both a major clinical responsibility and a respected research output will inevitably become a centre of excellence for post-graduate training.

Finally, many of our colleagues in other specialties are only grudgingly coming round to the recognition of the importance of the link between anaesthesia and intensive therapy. If the holder of this post is able to withstand critical peer review at multidisciplinary scientific meetings, this link will become more strongly forged.

It is the intention of the two bodies which have established this post to make it possible for an anaesthetist to fulfil these ambitions. Ultimately it may be possible to establish an independent university department of intensive therapy with a permanent infrastructure.

This is an exciting development. The department which obtains the grant and the successful applicant for the post will have a high profile. It is to be hoped that the success of this venture leads to an improvement in the academic standing of United Kingdom anaesthetists in the field of intensive therapy.

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Reference

1. Intensive Care Services; Provision for the Future. Association of Anaesthetists of Great Britain and Ireland, London, 1988.

Editorial notices

Anaesthesia News

Copy for *Anaesthesia News* should be sent to the Editor as and when it becomes available. It is hoped that publication will occur within 2 months of receipt.

Manuscripts must be submitted in accordance with the internationally recognized *Uniform requirements for manuscripts submitted to biochemical journals* (*British Medical Journal* 1979; 1: 432-5). Details will be found in the Notice to Contributors to *Anaesthesia* at the end of this issue.

A comparison of anaesthetic breathing systems during spontaneous ventilation

An *in-vitro* study using a lung model

A. S. H. CHAN, W. E. BRUCE AND N. SONI

Summary

Five anaesthetic breathing systems (Magill, Lack, Humphrey ADE, enclosed Magill and Bain) were compared using spontaneous ventilation in a simple lung model. The fresh gas flow at which rebreathing occurred was determined for each system by the application of four modified definitions of rebreathing. Two were based on the measurement of minimum inspired and two on end-expired carbon dioxide. The four A systems performed similarly with each individual definition. The rebreathing points found for each individual breathing system differed markedly between definitions, with those determined by the minimum inspired CO_2 occurring at low, and probably misleading, FGF/\dot{V}_E ratio. The Bain system demonstrated rebreathing at considerably higher fresh gas flows whichever definition was used.

Key words

Equipment; breathing systems.

Ventilation; alveolar.

In 1954 Mapleson described the theoretical analysis of semiclosed anaesthetic breathing systems.¹ Since then several new breathing systems have been introduced which have been advocated for use in spontaneous breathing. These include the Lack,² the Humphrey ADE³ and the enclosed Magill⁴ breathing systems which are all A systems, and the Bain⁵ which is technically a D system. There have been a large number of clinical studies comparing these various different breathing systems for spontaneous ventilation in man.^{6–13} Controversy resulted from the conclusions and subsequent recommendations of several of these studies. There was debate with regard to the relative efficiency of the Lack and Magill breathing systems,^{11,14–16} as well as considerable discussion concerning the requisite fresh gas flow when using the Bain breathing system for patients breathing spontaneously.^{9–12,17–19}

There are several potential reasons for the wide range of results. Some studies have used conscious volunteers, others anaesthetised patients and a wide range of anaesthetic techniques have been employed. The patients have been anaesthetised but unstimulated,²⁰ anaesthetised and surgically stimulated,^{7,21,22} or anaesthetised with both general and regional anaesthesia and therefore theoretically unstimulated.^{10,13} Apart from these general differences there are physiological variations, between individuals,

which are difficult to measure and may influence the onset of rebreathing. These include the production of carbon dioxide, the physiological deadspace during anaesthesia as well as the variability of response of subjects to both breathing through an anaesthetic system and to the onset of rebreathing.

The point of rebreathing has been defined in different ways in previously reported studies and the criteria used to determine this point may also be a source of disagreement.

The purpose of this study was to circumvent some of these problems by the use of a lung model to assess both the function of the breathing systems and the criteria which determine the point of rebreathing. The model is not directly comparable with a human lung, but it does enable many of the variables, relating to both anaesthetic circumstances and patient differences, to be controlled and thereby facilitates comparisons of the breathing systems under identical conditions.

Since the completion of the experimental work reported here, Miller²³ has published a similar study using a lung model to evaluate the function of breathing systems during spontaneous ventilation. The ambiguities associated with the definitions of rebreathing were discussed but, in that study, the problem was avoided by determining the effective alveolar ventilation and defining rebreathing as the point at which functional dead space starts to increase.

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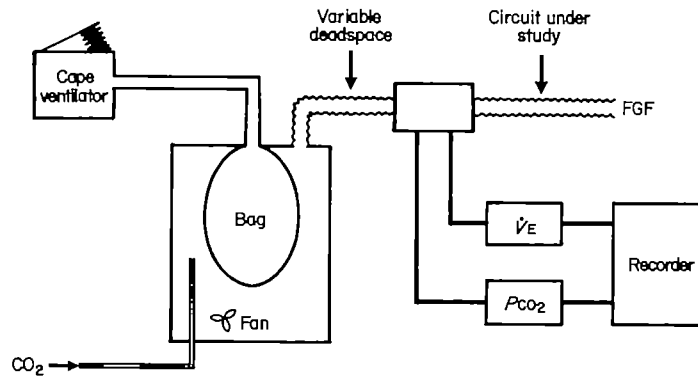


Fig. 1. The lung model. A bag-in-bottle design in which the space between the bag and the bottle acts as the lung. Carbon dioxide is introduced into the lung and mixed by the fan. A Cape ventilator produces a sine wave ventilatory pattern. \dot{V}_E and P_{CO_2} are recorded continuously.

The changes in functional deadspace were measured in relation to fresh gas flow and then used to determine the fresh gas flow requirements for the breathing system. The functional similarity of the A systems was clearly shown as was the markedly different performance of the Bain system.

In the study reported here, the Lack, which is the source of some controversy^{11,14-16} is included. The other important aspect of this study was to apply four different versions of the criteria for rebreathing to each system to assess both the systems and the criteria.

Method

A lung model was designed, which uses the bag-in-bottle principle (see Fig. 1). The model consists of a 2-litre antistatic bag inside a 6-litre cylindrical plastic airtight container. This allows free movement of the bag. The bag is connected to a modified Cape ventilator which merely pushes air in and out of it. This draws gas from the breathing system into the bottle and then expresses gas from the bottle. The space between the rebreathing bag and the plastic bottle acts as the 'alveolar' part of the lung. Carbon dioxide, through a calibrated Rotameter, can be introduced into the 'lung' through a fine bore tube in the plastic container, which minimises the effects of varying pressure on flow. The flows are checked at the end of each study. A small electric fan is situated on the base of the container to ensure adequate mixing of fresh gas and carbon dioxide within the 'lung'. The lung itself is connected by a length of plastic tubing to the breathing system being tested. The volume of plastic tubing is assumed to act as both an anatomical and physiological deadspace. This volume is easily measured and can be altered.

A Hewlett-Packard capnograph sensor and a Wright electronic spirometer were mounted at the end of the deadspace. They were used to measure continuously the partial pressure of carbon dioxide and the expired total ventilation respectively (\dot{V}_E). The (modified) Cape ventilator was employed to produce a sine wave ventilatory pattern which was not modified during the study. (I:E 1:1).

The lung model was validated in the first part of the experiment. The lung was ventilated at a rate of 15 breaths/minute with a carbon dioxide production (\dot{V}_{CO_2})

of 200 ml/minute and with a deadspace (V_D) of 150 ml. The end-tidal carbon dioxide ($P_{E'}CO_2$) was measured. The tidal volume was then reduced stepwise from 800 to 300 ml and the $P_{E'}CO_2$ recorded. The measured $P_{E'}CO_2$ values at each tidal volume were then compared with the values derived from the mathematical equation.

$$F_{ACO_2} = F_{ICO_2} + \dot{V}_{CO_2}/\dot{V}_A$$

The fresh gas flow at which rebreathing occurred, the point of rebreathing, was estimated according to four definitions for each of the five breathing systems in the second part of the study.

The ventilation parameters were those appropriate for an adult of 70 kg. The lung was ventilated with a tidal volume of 700 ml, deadspace to tidal volume ratio (V_D/V_T) of 0.4, ventilatory rate of 12/minute and CO_2 production (\dot{V}_{CO_2}) of 200 ml/minute. This results in a total ventilation of 8.4 litres/minute and a calculated $F_{E'}CO_2$, in the absence of rebreathing, of 0.4. The fresh gas flow was then incrementally reduced from a value of twice the total ventilation (16.8 litres/minute) down to a value of $0.4 \times$ the total ventilation (3.4 litre/minute). Stabilisation was allowed to take place before the partial pressure of end-tidal ($P_{E'}CO_2$) and minimum inspired carbon dioxide ($P_{Imin}CO_2$) was recorded after each incremental reduction in fresh gas flow. Stabilisation was defined to have occurred when there was no further change in $P_{E'}CO_2$ over a 10-minute period.

Modifications of four approaches to the definition of rebreathing were used to assess the point at which rebreathing occurred with each breathing system. The four definitions (in the modified form) are as follows:

- End-tidal carbon dioxide ($P_{E'}CO_2$) rising by 0.65 kPa;²¹
- End-tidal carbon dioxide ($F_{E'}CO_2$) rising by 0.25;⁶
- Minimum inspired carbon dioxide ($P_{Imin}CO_2$) rising by 0.25 kPa;¹¹
- Minimum inspired carbon dioxide ($F_{Imin}CO_2$) rising by 0.2.¹³

This experiment was repeated with each of the five breathing systems, the Magill, the Lack (MIE), the enclosed Magill, the ADE (MIE) and the Bain system (coaxial FGF). Physical characteristics of the expiratory limbs expressed as length (metres), volume (ml) were: Lack, 1.44 m, 330 ml; enclosed Magill and ADE, 1.44 m, 560 ml; and Bain, 1.8 m, 510 ml.

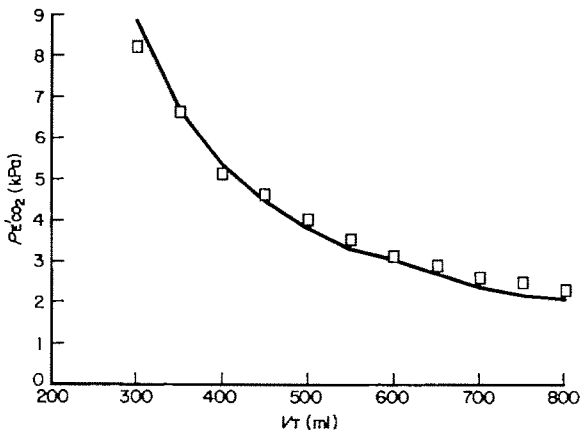


Fig. 2. A comparison of the end-tidal CO₂ tension derived mathematically (solid line) with the measured values from the model with no added breathing system.²⁴ $\dot{V}_D = 150$ ml, \dot{V}_{CO_2} 200 ml/minute, respiratory rate 15/minute.

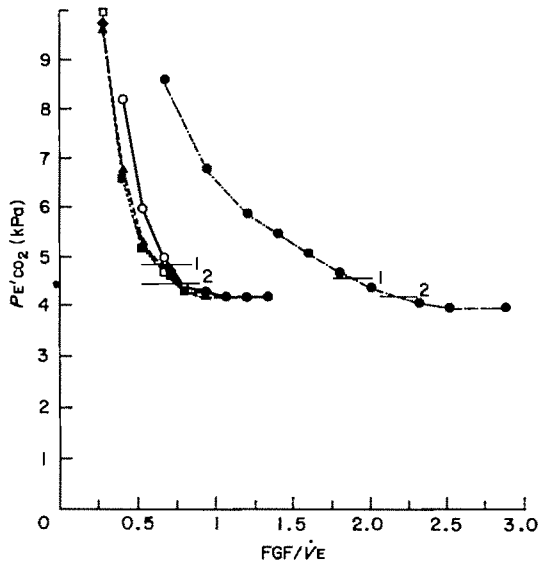


Fig. 3. End-tidal CO₂ tension ($PE'CO_2$) using the five breathing systems as the fresh gas flow is reduced. $PE'CO_2$ plotted against the FGF/\dot{V}_E ratio. First and second definitions marked. $\dot{V}_{CO_2} = 200$ ml/minute; \dot{V}_D/\dot{V}_T 0.4, \dot{V}_T 700 ml, rate 12/minute. ♦, Magill; □, ADE; ▲, enclosed Magill; ○, Lack; ●, Bain.

Finally, each of the four type-A breathing systems were studied with a range of different tidal volumes and with proportionate CO₂ production. The \dot{V}_D/\dot{V}_T ratio was kept constant at 0.4. The fresh gas flow was incrementally reduced from twice the total ventilation to 0.4 total ventilation. This was repeated at each tidal volume and the point of rebreathing determined by each of the methods mentioned previously.

Results

The lung model was validated using a similar method to that used by Sykes.²⁴ The mathematically derived alveolar carbon dioxide concentration over the range of tidal volumes tested are plotted along with measured $PE'CO_2$ readings from the lung model. Figure 2 shows that the mathematical predictions lie close to the measured values. At 11 points of measurement the mean difference (SD) in values was 0.16 (0.09) kPa.

Table 1. Points of rebreathing for the five anaesthetic breathing systems using different rebreathing criteria. Parameters chosen mimic a 70 kg adult anaesthetised with spontaneous ventilation were $\dot{V}_T = 700$ ml, respiratory rate = 12/minute; $\dot{V}_{CO_2} = 2$ ml/minute; \dot{V}_D/\dot{V}_T 0.4, $\dot{V}_A = 0.6 \times \dot{V}_T$.

	Magill	Lack	ADE	Enclosed Magill	Bain
$PE'CO_2$	0.65	0.71	0.63	0.65	1.86
0.65 kPa ²¹	78	85	76	78	223
$FE'CO_2$	0.72	0.76	0.74	0.75	2.2
0.25% ⁶	86	91	89	90	264
$PICO_2$	0.4	0.5	0.33	0.39	1.47
0.035 kPa ¹¹	48	60	40	47	176
$FI'CO_2$	0.43	0.53	0.36	0.42	1.53
0.2% ¹³	52	64	43	50	183

In each pair: top row, FGF/\dot{V}_E ratio; bottom row, FGF ml/minute.

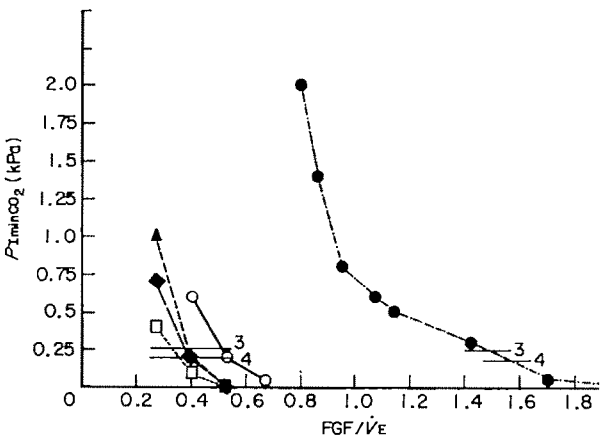


Fig. 4. Minimum inspired carbon dioxide ($PICO_2$) using the five breathing systems as the fresh gas is reduced. $PICO_2$ plotted against FGF/\dot{V}_E ratio. Third and fourth definitions marked. $\dot{V}_{CO_2} = 200$ ml/minute; \dot{V}_D/\dot{V}_T 0.4, \dot{V}_T 700 ml, rate 12/minute. □, Magill; ▲, ADE; ●, enclosed Magill; ○, Lack; ♦, Bain.

The partial pressures of end tidal and minimum inspired carbon dioxide were measured as the fresh gas flow was reduced using each breathing system in turn. Figure 3 shows the $PE'CO_2$ is plotted against the fresh gas flow (FGF) in terms of the FGF/\dot{V}_E ratio. Rebreathing was demonstrated in all the Mapleson type A systems (defined by a rise of end-tidal carbon dioxide) at a FGF/\dot{V}_E ratio of between 0.63–0.71 or 0.72–0.75 depending on whether the first or second definition is used. There is little difference between them. Rebreathing was demonstrated with the Bain, D system, at a ratio of either 1.86 or 2.2 using these definitions. The exact values for each system with either definition are in Table 1.

However, when the change in minimum inspired carbon dioxide is used to define the rebreathing point, then this occurs at a FGF/\dot{V}_E ratio of 0.33 or 0.36 for the ADE, 0.4 or 0.43 for the Magill, 0.39 or 0.42 for the enclosed Magill and 0.5 or 0.53 for the Lack (Fig. 4), again depending on whether the third or fourth definition is used. The Bain demonstrates rebreathing, by these criteria, at a FGF/\dot{V}_E ratio of 1.47 or 1.53 (see Table 1). When alterations in tidal volume were made, with accompanying proportionate changes in CO₂ production, it was noted that there was no change in the ratio of FGF/\dot{V}_E at which rebreathing

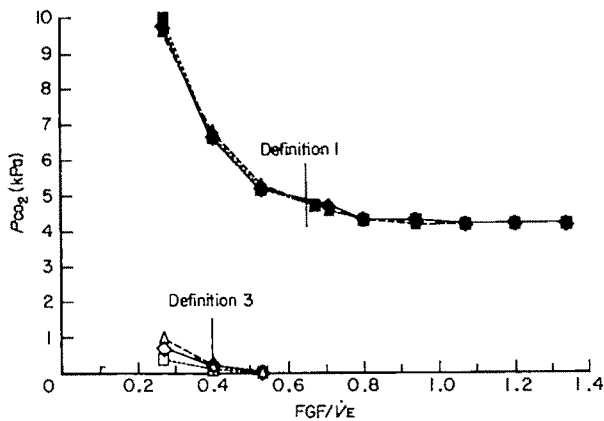


Fig. 5. P_{ECO_2} and P_{ICO_2} using the ADE, enclosed Magill and the Magill plotted against FGF/\dot{V}_E . The rebreathing points of the Magill using the first and third definitions are demonstrated. \dot{V}_{CO_2} 200 ml minute; V_D/V_T 0.4; V_T 700 ml, 12/minute. ♦, Magill P_{ECO_2} ; ◇, Magill P_{ICO_2} ; ■, ADE P_{ECO_2} ; □, ADE P_{ICO_2} ; ▲, enclosed Magill P_{ECO_2} ; △, enclosed Magill P_{ICO_2} .

occurred. This was a consistent finding with tidal volumes of between 300 ml and 1000 ml. The rebreathing point ($P_{E'}CO_2$: 0.65 kPa) using the Magill at these tidal volumes occurred at a mean FGF/\dot{V}_E ratio of 0.68 (SD 0.04), the Lack 0.7 (SD 0.05), the enclosed Magill 0.7 (SD 0) and the ADE 0.67 (SD 0.05).

Discussion

There are two main findings from this study. The first is that while all four A systems perform in a similar manner, they are quite different from the Bain D system. The second finding is that the onset of rebreathing using criteria based on $P_{E'}CO_2$ is markedly different from when $P_{\text{min}}CO_2$ is used.

Several definitions of rebreathing were used in this study to identify the point at which rebreathing started, and thereby compare the function of the breathing systems. All four type A systems performed similarly, as can be seen from Figure 3, with rebreathing occurring at an FGF/\dot{V}_E ratio of between 0.63 and 0.75 when the end-tidal CO_2 -based definitions were used. This is in contrast to the Bain system where rebreathing occurred at a ratio of between 1.86 and 2.2. There are minimal differences between the individual A systems, but they all perform markedly more efficiently than the D when compared on the lung model.

The A systems were similar, when the minimum inspired carbon dioxide concentration was used to define the rebreathing point, with rebreathing occurring at an FGF/\dot{V}_E ratio of between 0.33 and 0.53. This is in contrast with the D system where values of 1.47 and 1.53 were found. The range of values found with the A systems varied more when the definitions using $P_{\text{min}}CO_2$ were applied than when $P_{E'}CO_2$ was the determinant. The ADE appears most efficient and the Lack appears slightly less efficient. Recent studies do not suggest that the Lack is less efficient when used in clinical practice,^{10,11} and the differences demonstrated with the model are difficult to interpret. The Lack was the only coaxial version of an A system tested so it is possible that this configuration may influence the results found with the model. Minor differences demonstrated on a lung model should not be extrapolated to clinical circumstances.

There is, in this study, a difference in the point of rebreathing depending on the definition used (see Fig. 5). Conway²⁵ suggested that 'if rebreathing is to be avoided in spontaneously breathing subjects, then the necessary fresh gas flow should be defined as that flow which prevents both ventilation and arterial carbon dioxide tension changing from the resting anaesthetised state'. Kain and Nunn²¹ stated that 'rebreathing may be said to be present when the mixed inspired gas reaching the alveoli contains a concentration of CO_2 greater than could be accounted for by the alveolar gas reinhaled from the patient's anatomical deadspace'. Humphrey,¹¹ by using the minimum inspired CO_2 as a parameter, implied that only if there is carbon dioxide in the inspired gas throughout the inspiratory phase, is rebreathing occurring. The approach used by Miller²⁹ is to avoid the term 'rebreathing' by using 'functional deadspace' and to define this as the inhalation of alveolar gas into the alveolar compartment. Therefore, rebreathing is demonstrated by an increase in functional deadspace. All four approaches have been used as means of determining a point of rebreathing. The first approach, which can be used in clinical practice, utilises easily measured parameters such as rising arterial or end-tidal carbon dioxide and changing total ventilation. The second definition requires evaluation of the carbon dioxide load in the inspired gas. This can be determined by the continuous measurement of carbon dioxide concentration throughout the inspiratory phase and then using the area under the curve to evaluate the mean values.^{22,27} Care must be taken both in the integration of the flow signal to evaluate volume and in the allowance for the time delays from the recording instruments. It is a more accurate method than the previous one, but it is not an absolute measure of rebreathing since late inspiratory CO_2 may only reach the anatomical deadspace, and it is not easily done in clinical practice. The third approach requires the measurement of the minimum inspired carbon dioxide concentration. This is a relatively easy measurement but may be a late indicator of rebreathing.²⁷ The fourth method, of Miller, is a fundamental and accurate measure of rebreathing but is not applicable clinically.

The four different approaches do not necessarily produce the same results. This study demonstrates that the two definitions based on $P_{E'}CO_2$ produce similar results as do the two definitions based on $P_{\text{min}}CO_2$ but that there is a marked difference between these two pairs of results. Both cannot identify the same point of onset of rebreathing. The results produced by using $P_{E'}CO_2$ are similar to those reported by Miller who used a fundamentally different approach, but one that actually measured the gas composition at the alveoli. With A systems the functional deadspace in the enclosed Magill, the ADE and the Magill increased at an FGF/\dot{V}_E of 0.72 as compared with 0.7 in this study. Also, from a theoretical viewpoint these results are as predicted.¹ If V_D/V_T is 0.4, the alveolar ventilation (\dot{V}_A) must be $0.6\dot{V}_E$. With no breathing system, $0.6\dot{V}_E$ of the fresh gas will reach the alveoli. If a breathing system is attached, and the fresh gas flow is less than $0.6\dot{V}_E$, then some expired alveolar gas must be rebreathed. Hence rebreathing is already present. Therefore, both the results from Miller's paper and the theoretical argument support the results using the $P_{E'}CO_2$, and therefore imply that at the rebreathing points found using this model with the definitions based on $P_{\text{min}}CO_2$, rebreathing is already occurring.

Similar discrepancies appear in the reported clinical studies. When the criteria based on $PE'CO_2$ and total ventilation are applied most studies suggest a value for FGF/\dot{V}_E of 0.7, for A systems.^{20,21,26} It is rather more difficult to evaluate the studies which have used $P_{\text{min}}CO_2$ as the results are reported as ml/kg/minute. Humphrey¹¹ reports the fresh gas flow requirement for the Lack and Magill, which just induces rebreathing, to be 51 ml/kg/minute and 72 ml/kg/minute respectively. The ratios are 0.59 for the Lack and 0.8 for the Magill if a body weight of 65 kg is assumed. Other studies,^{7,13} using similar criteria, report surprisingly low fresh gas flow requirements for A systems (ADE 45 and 51 ml/kg/minute, Magill 56 ml/kg/minute), which may reflect low FGF/\dot{V}_E ratio.

The different results produced using the two methods may be part of the explanation for the wide range of fresh gas flow requirements reported for A systems. It also raises the question of the validity of using the $P_{\text{min}}CO_2$ as a means of evaluation of the rebreathing point.²⁷ It is true to state that if the minimum inspired PCO_2 is raised, rebreathing is occurring, but it is not correct to suggest that a minimum value of zero implies no rebreathing. It merely indicates that at a point in the inspiratory phase some fresh gas was at the sampling position but this does not necessarily reflect the composition of gas entering the alveoli.

It was of interest to note that during this study alterations in the tidal volume, with consistent alterations in carbon dioxide production and a constant \dot{V}_D/\dot{V}_T ratio, did not influence the point of onset of rebreathing, in terms of the FGF/\dot{V}_E at which it occurred. This is as anticipated by theoretical considerations. If rebreathing occurs when expired alveolar gas is reintroduced into the alveoli then rebreathing does not occur provided the fresh gas flow is the same or greater than the alveolar ventilation, \dot{V}_A . \dot{V}_A is the proportion of \dot{V}_E which has entered the alveoli and this is determined by the \dot{V}_D/\dot{V}_T ratio.

If $\dot{V}_A = FGF$ at the point at which rebreathing commences

and $\dot{V}_A = \dot{V}_E(1 - \dot{V}_D/\dot{V}_T)$

then $FGF/\dot{V}_E = (1 - \dot{V}_D/\dot{V}_T)$.

The value of this expression is constant and therefore the point of rebreathing is also constant, when expressed in terms of the ratio FGF/\dot{V}_E . Therefore values of FGF requirements are likely to be more consistent when expressed in terms of a fraction or multiple of total ventilation than in terms of ml/kg/minute. This consistency was demonstrated in the study but the value demonstrated for $(1 - \dot{V}_D/\dot{V}_T)$ was $0.7\dot{V}_E$, not $0.6\dot{V}_E$ which is the predicted value. The reason for this is probably that the theoretical prediction assumes no mixing of dead space and alveolar gas in the ideal situation, while in the model mixing almost certainly occurs.

In summary, the similarities of the four A systems are demonstrated by the study as is the marked difference of the function of the Bain system used in this mode. The differences in fresh gas flow requirements depend on which parameters are used to define the point at which rebreathing occurs and are demonstrated and it is suggested that the lower values found using minimum inspired CO_2 overestimate the efficiency of the breathing systems.

Acknowledgment

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Propofol-induced anaesthesia

Double-blind comparison of recovery after anaesthesia induced by propofol or thiopentone

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Summary

Postoperative psychomotor and cognitive recovery were assessed after anaesthesia induced by either propofol or thiopentone, and maintained with nitrous oxide and halothane in 40 unpremedicated dental patients. Performance was shown to be impaired one hour postoperatively for the whole sample in hand-eye coordination ($p < 0.001$), reaction time ($p < 0.001$) and digit span ($p < 0.05$). There was evidence of impairment at 3 hours postoperatively in reaction time ($p < 0.05$) and ataxia ($p < 0.01$). Performance also deteriorated in the dexterity and aiming tasks. Patients reported significantly less clumsiness by 24 hours in blurred vision and shivering ($p < 0.05$) and by 48 hours less coughing ($p < 0.05$). However, there was no significant difference between groups. No evidence showed that recovery in the propofol group was faster, so it was concluded that induction with propofol offered no advantage when anaesthesia is maintained with nitrous oxide and halothane for the periods of time reported in this study.

Key words

Anaesthetics, intravenous; thiopentone, propofol.

Recovery.

Propofol is an intravenous induction agent also used for maintenance of anaesthesia,^{1–7} and is compatible with a range of premedicants, neuromuscular blocking drugs and other anaesthetic agents. Recovery from propofol is much quicker than from other anaesthetic agents,^{8,9} and some benefits persist up to 2 days after anaesthesia with propofol as the sole anaesthetic agent (Yeomans, Clyburn, Rosen and Robinson, unpublished observations).

This present study assesses the quality of anaesthesia and psychomotor recovery pattern of patients following induction of anaesthesia with either propofol or thiopentone and maintenance with nitrous oxide and halothane.

Methods

The study was approved by the Hospital Ethics Committee. Patients, ASA 1 and 2, aged between 16 and 65 years scheduled for daycase dental procedures after informed consent had been given, were randomly allocated to two groups, which received either propofol or thiopentone as induction agent. Exclusions were made in the case of previous adverse experience of general anaesthesia, pregnancy, gross obesity and those taking any drugs or medication likely to influence the course of anaesthesia.

Procedure

Both the patient and the psychologist who assessed recovery were blind to the identity of the induction agent. Each patient, unpremedicated, was instructed and allowed to become familiar with the psychometric tests on arrival at the hospital, after which baseline measures were taken. An 18-gauge cannula was inserted in a peripheral vein and flushed with lignocaine 10 mg on arrival in the operating theatre. Baseline pulse and arterial blood pressure readings were taken using a Hewlett-Packard HP 78352A monitor. Anaesthesia was induced with either propofol or thiopentone, titrated until unconsciousness occurred, gallamine 10 mg and suxamethonium (1 mg/kg). A nasotracheal tube and a throat pack were inserted and anaesthesia maintained with the patient breathing spontaneously through a Bain co-axial system 70% nitrous oxide in oxygen, with added halothane 1–3% as indicated by the response to surgery. Blood pressure and pulse rate were recorded 2 minutes after administration of the induction agent and subsequently at 5-minute intervals. The occurrence of apnoeic episodes, coughing or movement during induction or maintenance was recorded. The inhaled anaesthetics were stopped and the trachea extubated at the end of surgery.

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Table 1. Details of patients. Values expressed as mean (SD).

	Propofol	Thiopentone
Age, years	28.7 (10.7)	23.4 (6.1)
Weight, kg *	67.2 (11.4)	59.4 (11.5)
Height, cm	169.1 (7.8)	164.2 (11.5)
Induction dose, mg	193.8 (51.8)	334.2 (83.8)
mg/kg	2.91 (0.71)	5.66 (1.31)

*p < 0.05 significant difference between groups (Anova).

The times at which each patient was able to open eyes, protrude tongue, give correct date of birth, sit up and stand unaided were recorded in the recovery room. Assessments of breathing, movement and the degree of wakefulness on the Steward Scale¹⁰ were made at 3, 5, 15 and 30 minutes after anaesthesia was stopped and on discharge from the recovery ward.

Psychomotor performance was assessed at 1 and 3 hours after the end of the procedure, and at the patient's home on the following day.

Psychometric tests

The tests in the battery assessed cognitive functioning, visual-motor impairment, reaction time and ataxia. Three tests were to measure visual-motor coordination, each assessing different component functions. All seven of the tests in the battery were standard psychometric measures with established use in psychological experimentation.

Stroop test. Two sets of 25 cards, on each of which is printed one word in a coloured ink, were presented to the patient who was requested to read aloud the ink-coloured word. On one set, the nonconflict set, the words were animal names, whilst on the conflict set were printed the names of colours, the name being different from the colour of the ink used for that card. The speed of reading each card set was recorded; the difference between the two times was an indication of ability to concentrate or attend to the task in hand.¹¹ The Stroop test examines impairment of high level intellectual function, and is shown to be effective in psychopharmacology.¹²⁻¹⁴

Digit span. Strings of numbers that increased in length from three upward were recited to the subject who had to repeat the string correctly, but in reverse order. This was continued until two consecutive errors were made; this gives an indication of short-term auditory memory capacity.¹⁵

Visualisation. Printed on a sheet of paper were eight sets of 10 interwoven curved lines. The task was to trace each line from its source to its end-point. A time limit of 90 seconds was set, with the number of lines traced correctly and incorrectly recorded to give an indication of ability to discriminate visual stimuli.¹⁶ This task is purely visual, and does not involve a motor component.

Aiming. Three hundred circles of 2-mm diameter linked in lines of 20 across a sheet of paper were presented to the subject who was asked to place a dot inside each circle within a time limit of 90 seconds. The number of dots correctly and incorrectly placed within and outside the circles are recorded. This assesses hand-eye coordination;¹⁶ both visual and motor processes have to function together.

Dexterity. The task is to guide a loop along a twisted length of wire; when the loop touches the wire a buzzing sound is emitted. The time taken for each hand was recorded as well as the number of touches. This task incorporates a visual component, but is primarily to assess manual dexterity.

Choice reaction time. This was measured by an apparatus with six buttons, arranged in an arc against a black background at equal distances from a central point, which light up in a randomised order. The task was to press the buttons as soon as the light appeared, returning the finger to the central point between presses. The time taken to do this was recorded by the apparatus.

Ataxia. The subject stood attached to an ataxiometer which measures the amount of forwards and backwards sway during a period of 15 seconds whilst the patient has closed eyes.¹⁷

Subjective effects

State anxiety was measured pre-operatively and the next day on a visual analogue scale with the ends labelled 'As anxious as I can imagine' and 'Not at all anxious'. Patients were presented with a sheet of Visual Analogue Scales for the following subjective after-effects at 3, 24 and 48 hours: shivering, feeling hot, sleepiness, headache, cough, nausea, vomiting, clumsiness, confusion, double vision, flush, depression, elation and weakness.

The psychometric data were tested using a paired *t*-test to seek evidence of impairment for the whole sample and then an analysis of covariance technique (Anova) was used, with the baseline measure taken as the covariate to control for individual differences in baseline performance.

Results

Data were collected for 40 patients. Ten of the propofol group were female and 15 of the thiopentone group, one of whom did not complete the psychometric assessment.

The details of the patients, as given in Table 1, show there to be no significant difference in age between groups (*p* > 0.05), but the propofol group, with a mean weight of 67.2 kg (SD 11.37), was significantly heavier than the thiopentone group, whose mean weight was 59.3 kg (SD 11.45; *p* < 0.05). However, there was no significant difference between groups in either height or weight/height ratio. The mean total dose of propofol was 193.8 mg, and of thiopentone 334.2 mg. The mean mg/kg dose for the propofol group was 2.91 (SD 0.71); for the thiopentone group 5.66 (SD 1.31).

The duration of surgery and recovery times (Table 2) show no significant difference between the groups for either the duration of surgery or of anaesthesia. For the propofol group the mean duration of the operation was 25.6 minutes and the mean time from induction to the end of inhalation was 34.7 minutes. For the thiopentone group the mean duration of the operation was 26.9 minutes and the mean time from induction to the end of inhalation was 36.2 minutes. None of these times showed a significant difference between groups. There was a low incidence of minor side effects at tracheal intubation, and no significant difference between groups (*p* > 0.05). The quality of induction and maintenance of anaesthesia was satisfactory in all patients. The propofol group tended to take less time to respond to re-

Table 2. Duration of surgery and recovery times, minutes. Values expressed as mean (SD).

	Propofol	Thiopentone
Duration of surgery	25.6 (11.4)	26.9 (16.8)
Induction to cessation of anaesthesia	34.7 (11.7)	36.2 (17.4)
Cessation of anaesthesia to:		
opening eyes	10.1 (5.9)	11.5 (4.6)
protruding tongue	11.1 (5.8)	14.2 (7.5)
orientation	14.1 (8.4)	16.2 (7.5)
sitting up	46.4 (26.6)	58.3 (31.5)
standing up	99.2 (31.7)	121.9 (34.0)

p > 0.05 (Anova).

Table 3. The Steward scores. Values expressed as mean (SD).

	Propofol	Thiopentone
3 minutes	1.7 (2.3)	0.7 (1.3)
5 minutes	2.2 (2.4)	1.2 (1.7)
15 minutes	5.1 (1.7)	4.8 (1.6)
30 minutes	6.0 (0.2)	5.8 (0.4)
At discharge	6.0 (0.0)	6.0 (0.0)

p > 0.05 (Anova).

covery tests, but at no point did this difference reach significance ($p > 0.05$). Furthermore (Table 3) the data from the Steward Scale also showed that the propofol group tended to have a higher mean score at the first four recovery points (3, 5, 15 and 30 minutes after the end of anaesthesia), but again at each point this difference failed to reach significance ($p > 0.05$).

Psychometric results

One patient who had propofol and two who had thiopentone were incapable of attempting the psychometric assessment at one hour. The psychometric results for the two drug groups are given in Table 4.

Cognitive functions. The data from the Stroop test provided no evidence of cognitive impairment. However, the scores from the digit span test were significantly lower for the whole sample at one hour ($p < 0.05$), which suggests impaired short-term auditory memory, but there was no evidence of impairment by 3 hours. However, there was no evidence of a significant difference between the groups ($p > 0.05$).

Visual-motor coordination. The results from the visualisation task for the whole sample showed a significant improvement in performance from baseline to the 3- and 24-hour test points ($p < 0.01$), which would indicate that performance on this task improved with practice. Therefore the lack of significant improvement at one hour could be taken as evidence of impairment, as patients had not improved on baseline performance. There was no evidence of a difference between groups ($p > 0.05$).

Compared with the baseline measurements in the aiming

Table 4. Psychomotor results (SD) by induction agent. Values expressed as mean (SD).

Test	Baseline		1 hour		3 hours		24 hours	
	Pr.	Th.	Pr.	Th.	Pr.	Th.	Pr.	Th.
Stroop	4.9 (5.2)	4.6 (5.3)	5.5 (13.3)	1.4 (3.8)	5.1 (3.4)	3.3 (4.4)	3.6 (3.3)	2.5 (2.0)
Digit span	4.9 (1.3)	4.7 (1.1)	4.7 (1.3)	4.3 (1.3)	5.1 (1.2)	4.5 (1.1)	4.9 (1.5)	4.6 (1.3)
Visualisation: correct	16.5 (6.3)	18.8 (4.1)	16.6 (5.8)	17.7 (6.0)	19.2 (6.7)	20.8 (5.4)	19.4 (8.4)	21.8 (7.2)
errors	0.9 (1.0)	0.3 (0.7)	0.5 (1.0)	0.3 (0.6)	0.7 (1.2)	0.1 (0.3)	1.1 (1.6)	0.8 (1.6)
Aiming: correct	133 (28)	147 (30)	117 (27)	123 (30)	143 (32)	155 (34)	147 (32)	165 (34)
errors	2.6 (6.4)	1.0 (2.6)	3.8 (8.6)	14.6* (26.9)	4.4 (10.3)	8.9 (17.9)	3.9 (13.7)	6.6 (15.5)
Dexterity: right-hand time	21.3 (9.1)	20.1 (8.2)	20.5 (9.3)	16.1 (6.1)	17.8 (6.5)	16.7 (5.5)	20.3 (7.8)	18.8 (7.0)
errors	3.8 (4.1)	4.6 (3.1)	9.7 (9.7)	7.0 (5.3)	5.5 (6.4)	6.3 (5.1)	4.1 (5.1)	2.9 (2.7)
Dexterity: left-hand time	22.0 (9.3)	18.5 (7.5)	23.1 (11.4)	17.4 (6.0)	20.8 (7.7)	19.2 (6.0)	23.3 (8.9)	21.2 (9.1)
errors	5.9 (4.3)	7.1 (5.1)	9.6 (7.7)	13.5 (6.0)	6.8 (6.4)	7.7 (4.0)	6.6 (5.3)	7.5 (5.5)
Choice reaction time	66.0 (9.7)	64.8 (9.5)	78.4 (25.1)	82.5 (19.7)	71.5 (20.6)	69.3 (10.2)	69.0 (15.4)	67.8 (14.1)
Ataxia	20.8 (9.2)	21.1 (9.0)	—	—	28.8 (31.3)	37.7 (17.1)	27.3 (15.6)	23.1 (9.4)

*p < 0.05, significant difference between groups (Anova).

task, patients completed significantly fewer circles correctly at one hour, ($p < 0.001$) and made more mistakes, ($p < 0.05$). They were still making more errors than pre-operatively ($p < 0.05$) at 3 hours, but had increased the number of correctly completed circles significantly above the baseline measures ($p < 0.05$), as also occurred at 24 hours, ($p < 0.05$).

The results from the dexterity task for the whole sample showed two trends: firstly patients made significantly more mistakes with each hand at one hour postoperatively, ($p < 0.001$) and at 3 hours there was evidence that the error rate with the right hand was still above baseline ($p < 0.05$). Secondly, patients took less time to complete the task than pre-operatively with the right hand at one hour ($p < 0.05$), 3 hours ($p < 0.01$) and 24 hours ($p < 0.05$). This suggests that they achieved speed at the cost of accuracy. The increased rate of completion coupled with a higher error rate on these two tasks, dexterity and aiming, may indicate an impairment in attention. Significantly more errors were made by the thiopentone group, ($p < 0.05$) at one hour. This could mean that the thiopentone patients were more impaired than those given propofol, but it is the only significant difference in a battery of 48 test results and a significant difference could be expected to appear in one of 20 results by chance.

Psychomotor functions. There was evidence that the patients' psychomotor functioning was impaired postoperatively. Patients were unable to stand at one hour, and for the whole sample at 3 hours the degree of involuntary sway as measured by ataxiometer was still significantly worse than the pre-operative level ($p < 0.01$). However there was no significant difference between groups. Reaction time for the whole sample at one hour was significantly longer than pre-operatively ($p < 0.01$), and although this effect was less marked by 3 hours it was still significantly above baseline ($p < 0.05$). Again there was no significant difference between groups.

Subjective effects results

Anxiety, by the following day as measured by visual analogue, had reduced significantly from the pre-operative level ($p < 0.001$) and there was no evidence of a difference between the drug groups ($p > 0.05$). Analysis of the visual analogues showed that the incidence of after effects had reduced from the 3 hours test. The sample reported feeling significantly less clumsy ($p < 0.05$) by 24 hours, and reported a lower incidence of blurred vision ($p < 0.05$) and shivering ($p < 0.05$). They reported significantly less sleepiness ($p < 0.001$) by 48 hours, less clumsiness and less weakness, and less coughing ($p < 0.05$). Sleepiness and headache had also significantly reduced between 24 and 48 hours ($p < 0.001$, $p < 0.05$). However, the visual analogues showed only one difference between the groups: at 24 hours the propofol group reported more coughing ($p < 0.05$).

Discussion

Commonly accepted ratios for equipotency for propofol and thiopentone range between 0.83 and 0.4.¹⁸⁻²¹ The ratio of equipotency in this study (since the doses were those required to produce unconsciousness) was 0.51 which accords with those figures. The results indicated that there was cognitive impairment across the sample as a result of

the anaesthetic drugs, but this was evident only in the memory task; the higher levels of functioning, as assessed by the Stroop test, did not seem to be significantly altered. Visual motor coordination was also shown to be impaired, as evidenced by the aiming and dexterity tasks. The tendency for patients to improve over time in the visualisation task suggests that this test may have been subject to learning effects, and consequently this may have masked the extent to which the purely visual component of visual motor coordination was affected by the drugs used.

It is, however, apparent that the motor functions of the patients were significantly affected by the anaesthetic drugs up to 3 hours later. This is shown in the data from all four tasks which required motor skills. These data suggest that patients are still significantly impaired in psychomotor functions at the time when they are customarily discharged from hospital.

However, unlike previous studies, these results show little difference in recovery between the groups. Their psychomotor responses were affected similarly, and there was little difference in the subjective ratings of after effects. The propofol group by chance were heavier, and more of them were female, so the data were re-analysed controlling for weight and sex. However, these analyses showed no evidence that the lack of comparability between the groups had suppressed an effect of the drugs.

The lack of advantage for the propofol group in this study contrasts with that of an earlier study using the same anaesthetic technique⁷ which showed the reaction times of the propofol group to be significantly faster than the thiopentone group 90 minutes postoperatively and over the following 2 days. The studies differ in the machinery used to measure reaction time, the times of the test points, and the use of premedication. However, it is not apparent that these factors could be expected to produce the contrasting results. Moreover, as five of the seven tests used in this battery showed significant evidence of impairment, it must be concluded that those tests were suitable for this type of assessment, and sensitive to the effects of the anaesthetic drugs used.

It would seem that the duration of halothane anaesthesia in this study must have reduced the advantage shown with propofol in previous research. Here it must be concluded from the results reported that there is no evidence of an advantage in using propofol as an induction agent for unpremedicated patients, when anaesthesia is subsequently maintained with nitrous oxide and halothane for the length of time of this present study.

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Propofol–fentanyl anaesthesia for coronary artery surgery and cardiopulmonary bypass

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Summary

A two-stage propofol infusion combined with fentanyl was used to maintain anaesthesia during coronary artery surgery in patients with good ventricular function. Whole blood propofol concentrations were measured at frequent intervals; plasma protein binding was measured before, during and after cardiopulmonary bypass. An initial infusion rate of 10 mg/kg/hour provided good protection from the pressor response to sternotomy. A predictable steady state concentration was achieved in the prebypass period with a maintenance infusion rate of 3 mg/kg/hour. The onset of bypass resulted in a small decrease in propofol concentration as a result of haemodilution. Induced hypothermia resulted in an increase in propofol concentration which returned rapidly to the prebypass steady state value during rewarming. The free propofol fraction increased during cardiopulmonary bypass. No patient had any recall of operative events or required inotropic support during weaning from bypass.

Key words

Anaesthesia; cardiovascular.

Anaesthetics, intravenous; propofol.

Propofol, a new intravenous anaesthetic agent, is suitable for maintenance of anaesthesia by infusion. It has been used recently for coronary artery surgery performed during cardiopulmonary bypass (CPB).^{1,2} Hypothermic CPB causes many physiological changes which have clinically significant effects on the disposition and elimination of drugs.³ This study was designed to assess the suitability of a two-stage propofol infusion for cardiac surgery and in particular to study the effect of hypothermic CPB on the kinetics of the drug.

Methods

The study received institutional ethics approval and each patient gave written informed consent. Ten male patients were studied; all were scheduled for coronary artery surgery with internal mammary artery anastomosis to the left anterior descending coronary artery. All had good or only moderately impaired ventricular function as defined by an ejection fraction of approximately 50%. All were receiving maintenance doses of a beta-adrenoceptor antagonist (metoprolol or atenolol), a calcium antagonist (nifedipine) and a nitrate (isosorbide dinitrate or glyceryl trinitrate). These drugs were continued up to and including the morning of operation.

Premedication consisted of sodium amylbarbitone 300 mg on the evening before operation and diazepam 10–15 mg one hour before operation. Radial artery pressure monitoring was established under local anaesthesia. Electrocardiographic (ECG) monitoring was applied and lead II displayed continuously. Anaesthesia was induced with fentanyl 25 µg/kg, diazepam 0.1 mg/kg and pancuronium 0.15 mg/kg, and the lungs were ventilated with oxygen-enriched air to normocapnia. An infusion of propofol at the rate of 10 mg/kg/hour was established through a dedicated peripheral arm vein 10 minutes before skin incision and continued for 15–20 minutes during which time sternotomy and sternal spread were performed. The infusion was then reduced to a maintenance rate of 3 mg/kg/hour until the final skin suture had been inserted. An additional dose of fentanyl 10 µg/kg was administered before the start of CPB. The time from the end of infusion to response to command was noted, and all patients were questioned postoperatively about dreaming or recall of operative events.

CPB was effected by cannulation of both venae cavae and the ascending aorta. The circuit, incorporating a membrane oxygenator, was primed with 3 litres of compound sodium lactate solution. Hypothermia to a nasopharyngeal temperature between 25°C and 27°C was induced with an in-circuit heat exchanger. A pump flow of 2.41 litres/minute/

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Table 1. Haemodynamic parameters before and during propofol infusion. Data are expressed as mean (SD).

	Awake	Postinduction	Postintubation	Presternotomy	Post-sternotomy
Heart rate (beats/minute)	70 (8)	69 (13)	71 (16)	75 (16)	78 (16)
Systolic arterial pressure (mmHg)	117 (17)	101 (8)	113 (20)	114 (13)	125 (14)
Mean arterial pressure (mmHg)	80 (12)	68 (3)	77 (11)	80 (11)	84 (13)
Diastolic arterial pressure (mmHg)	63 (11)	52 (3)	60 (8)	63 (11)	67 (12)

sq m body surface area was maintained during normothermia but reduced to 1.81 litres/minute/sq m during hypothermia.

Measurements of heart rate (HR), systolic (SAP), mean (MAP) and diastolic arterial pressure (DAP), were measured in the awake state, after tracheal intubation and after sternotomy using a transducer calibrated against a mercury manometer. In addition, any requirement for inotropic support during weaning from CPB was noted.

Whole blood samples (3 ml) for measurement of propofol concentrations were collected from the indwelling radial artery cannula into tubes that contained lithium heparin at 5-minute intervals during the initial propofol infusion and also at 5-minute intervals from 30 minutes after the start of the maintenance infusion until bypass. During bypass, eight to 14 samples were taken from the pump arterial line during the cooling phase and two to six during the rewarming phase. Seven to 12 samples were taken from the radial artery cannula after bypass. Plasma samples for propofol protein-binding estimation were taken from three subjects. The propofol concentrations in blood and plasma/dialysis buffer were determined by the high pressure liquid chromatographic method described by Plummer.⁴ Propofol plasma protein-binding on samples collected into lithium heparin and stored at +4°C was estimated using the 'Dianorm' equilibrium dialysis method described by Weder *et al.*⁵

A separate *in vitro* study was performed after the acquisition of the *in vivo* protein binding results. The aim was to determine whether heparin had any direct effect on protein-binding of propofol. Blood samples from three healthy young volunteers were taken into flasks that contained potassium oxalate (to a final concentration of 3 mg/ml) and lithium heparin (0.15 and 0.19 mg/ml). The plasma was removed, pooled for each anticoagulant, spiked with ¹⁴C-propofol over the concentration range 0.5–5 µg/ml and subjected to equilibrium dialysis as above. Propofol concentrations were determined by scintillation counting.

Statistical analysis of the haemodynamic data was undertaken with a paired *t*-test. A *p* value of <0.05 was taken to be significant.

Results

The mean age of the patients was 53 years (range 32–65 years). The mean weight was 75.6 kg (range 60–90 kg).

There was no significant haemodynamic response to tracheal intubation. The slight increase in arterial pressure in response to sternotomy was neither clinically nor statistically significant (Table 1). One patient received 0.5% enflurane in the prebypass period because of sweating and apparently light anaesthesia. None of the patients required inotropic support during weaning from CPB, and none had ECG or cardiac enzyme evidence of myocardial infarction in the peri-operative period.

Propofol concentrations increased rapidly during the 10 mg/kg/hour infusion to reach a mean (SEM) concentration of 4.85 (0.23) µg/ml at 15 minutes. Concentrations were generally stable from the earliest sampling time (30 minutes) after the start of the 3 mg/kg/hour infusion; on average, seven samples were taken during this period. Individual mean concentrations for all samples taken during the second infusion up to bypass ('apparent steady state') ranged from 1.81 to 2.77 µg/ml with an overall mean of 2.38 µg/ml. The onset of CPB was accompanied by a rapid decline in concentrations; individual trough levels ranged from 50.5% to 78.0% of the corresponding mean prebypass values and occurred at 2 to 10 minutes after the start of CPB. Thereafter, the propofol concentrations recovered rapidly, and reached an overall mean of 98.2 (5.4) % of the prebypass concentration by 20 minutes after the start of CPB. This upward trend continued during hypothermic CPB to reach an overall mean concentration of 2.80 (0.14) µg/ml, or 118 (5) % of the mean prebypass values. Concentrations decreased to 101 (6)% of the mean prebypass values 20 minutes after the start of rewarming. The propofol concentration increased slightly during the postbypass infusion in all patients. The mean ratio of radial arterial to pump arterial concentrations (*n* = 6) was 1.000 (0.001), and this confirmed the validity of using the two sampling sites. The whole blood propofol concentrations at specific time periods are displayed on a representative time scale in Figure 1.

The free fraction of propofol in plasma ranged from 3.5% to 6.6% before CPB and increased by a factor of 1.5 to 3 during bypass. The free fraction after CPB decreased to prebypass values in two patients and increased to approximately twice the prebypass value in the third.

The mean proportion of ¹⁴C-propofol unbound in plasma was 3.0 (0.3)% (*n* = 16), 2.0 (0.1)% and 2.4 (0.0)% for blood drawn from healthy young volunteers into potassium oxalate (3 mg/ml), or lithium heparin (0.15 and

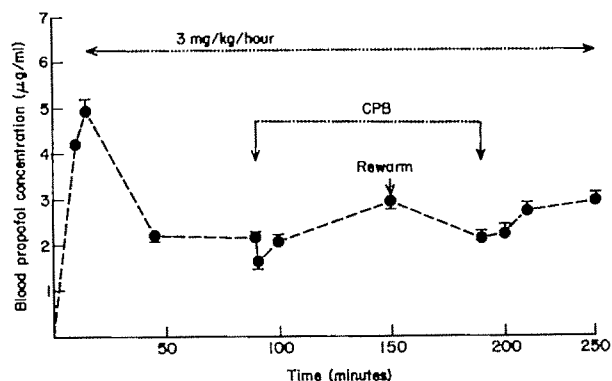


Fig. 1. The fluctuations in blood propofol concentration throughout the operative procedure. The time scale shows the mean time taken to specific events such as the onset of cardiopulmonary bypass (CPB), induced hypothermia, and the end of bypass. Bars represent SEM.

0.19 mg/ml) respectively. There was no trend in protein binding with propofol concentration over the range 0.5–5 µg/ml.

The mean (SD) time from end of infusion to movement on command was 65 (23) minutes. No patient experienced dreaming or had any recall of operative events when questioned 2 days and 2 weeks after the procedure.

Discussion

The administration of the rapid initial infusion (10 mg/kg/hour) of propofol served as a loading infusion for the 3 mg/kg/hour maintenance rate with the result that an 'apparent steady state' concentration had been achieved after 30 minutes at this lower rate. It has been reported that fentanyl reduces the clearance of propofol administered as a single bolus dose.⁶ However, the mean (SEM) apparent steady state value of 2.38 (0.10) µg/ml in our study group is very similar to the calculated steady state value (2.43 µg/ml) when the same infusion rate was administered to normotensive patients who underwent body surface operation and who did not receive fentanyl.⁷ Thus, no obvious effect of fentanyl on the pharmacokinetics of propofol was seen in this study.

Propofol was not used for induction of anaesthesia. A pilot study using a bolus dose of 1.5 mg/kg resulted in a high incidence of hypotension, which occasionally required intervention with vasopressors. Patrick *et al.*⁸ also reported a variable and sometimes severe reduction of arterial pressure after a bolus dose of 1.5 mg/kg in patients with coronary artery disease. This would be unacceptable in our high risk study group, all of whom had disease of at least three coronary vessels. The lack of significant pressor response to intubation after induction of anaesthesia with moderate doses of fentanyl and diazepam is in keeping with our usual experience. Hypertensive responses to sternotomy and sternal spread are ablated poorly even by very high doses of fentanyl as the sole anaesthetic.^{9–10} However, the use of the 10 mg/kg/hour infusion of propofol during this period was accompanied by excellent haemodynamic stability.

The infusion was reduced to 3 mg/kg/hour after sternotomy when surgical stimulation was less intense. This constant rate infusion facilitated the determination of changes in propofol concentration with kinetically important events such as the onset of CPB. However, this dose is not adequate for all patients as demonstrated by the requirement for supplemental enflurane in one patient in the prebypass period.

The rapid but transient decrease in propofol concentrations after the onset of CPB was due primarily to acute haemodilution with the 3-litre crystalloid pump prime. The recovery to prebypass concentrations by about 20 minutes results probably from a combination of redistribution of propofol from tissues into blood and the physiological changes that result from the onset of bypass. Distribution of propofol occurs rapidly after a single bolus dose (distribution half-life 2–4 minutes)^{6–11} and equilibrium of this phase is achieved 10–15 minutes after administration. It would be expected that distribution equilibrium after haemodilution should be achieved in a similar time.

The clearance of propofol is dependent on liver blood flow.⁶ Hepatic perfusion is reduced during hypothermia as a result of intrahepatic shunting of blood.¹² Systemic perfusion (and thus hepatic blood flow) is also reduced at this

time. In addition, hepatic microsomal enzyme activity is reduced in a temperature-dependent fashion. These processes would be expected to reduce propofol clearance and may explain the overshoot to blood concentrations higher than those observed before bypass. The rapid decrease in blood concentrations during rewarming to a value identical to those observed before bypass confirms the rapid reversibility of the physiological changes during hypothermic bypass; clearance rates for propofol had returned to prebypass levels after 20 minutes of rewarming. The slight increase in concentration after the termination of bypass was a result of the infusion of residual blood that contained propofol from the pump reservoir.

The trends observed in this study are very similar to those reported for etomidate¹³ during a zero-order infusion of the agent, as would be expected from a drug with a similarly high clearance rate. The observed decrease in propofol protein-binding during bypass, and recovery after bypass, are similar to those reported for thiopentone¹⁴ during an exponentially decreasing infusion rate for procedures that involved CPB. The changes in binding may be related to competition for protein-binding sites by free fatty acids released by stimulation of lipoprotein lipase activity after heparin administration. Similar alterations in protein-binding after heparin administration have been noted with other drugs.¹⁵ Lithium heparin was used as the anticoagulant for all samples taken in this study and would have been present in blood samples at a concentration of approximately 0.15 mg/ml prebypass and up to 0.2 mg/ml during bypass. No displacement of propofol from protein-binding sites in volunteer blood was observed with these concentrations of heparin compared with blood taken into potassium oxalate. No precautions were taken to inactivate lipoprotein lipase in blood samples collected from the patients; it is possible that free fatty acid release, initiated *in vivo*, continued *in vitro* and resulted in increased displacement of propofol from protein-binding sites.

This propofol-fentanyl anaesthetic technique may have a number of advantages for coronary artery surgery. An anaesthetic technique based on high dose opioids alone may necessitate prolonged ventilation and larger quantities of vasopressors, and fluids may be required in the postoperative period in comparison with alternative techniques.¹⁶ If a technique based on volatile anaesthetic agents is used during CPB the concentration is usually reduced considerably before weaning from bypass in order to avoid myocardial depression;¹⁷ at this time the patients are normothermic and awareness associated with this procedure is well documented.¹⁸ The constant infusion of propofol at 3 mg/kg/hour during bypass was not associated with dreaming or recall of operative events. However, care must be taken in extrapolation from a study group of this size, particularly if different doses of adjuvant anaesthetic agents are used.

None of the patients required inotropic support during weaning from CPB despite therapeutic blood propofol levels at the end of the procedure. The haemodynamic effects of propofol at 1 MIR (Minimum Infusion Rate)¹⁹ are not significantly different from those of Althesin, and result in less myocardial depression than equipotent concentrations of any of the volatile anaesthetic agents. Thus the possibility of awareness should be reduced considerably without the haemodynamic sequelae of the volatile an-

aesthetic agents or the prolonged depression of ventilation associated with high-dose opioids. The two-stage propofol infusion combined with a moderate dose of fentanyl achieved good haemodynamic stability and prevented the pressor response to sternotomy. The changes in blood propofol concentration during CPB were predictable, and anaesthesia was maintained without compromising the restoration of spontaneous circulation. The combination of low-dose opioid and rapidly cleared hypnotic should facilitate early extubation after cardiac surgery. A larger comparative study would be necessary to evaluate further this potential advantage of the technique.

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Alfentanil requirement in Crohn's disease

Increased alfentanil dose requirement in patients with Crohn's disease

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Summary

The dose requirement of alfentanil as a supplement to nitrous oxide anaesthesia was studied in 13 patients with Crohn's disease and seven control patients all of whom underwent laparotomy. Alfentanil was administered as a variable rate infusion with supplemental bolus injections titrated to the patient's needs. The alfentanil requirement was independent of the duration of surgery and was significantly higher in patients with Crohn's disease than in control patients. The results indicate that Crohn's disease alters the dose requirement of alfentanil.

Key words

Analgesics; alfentanil.

Surgery; laparotomy.

The pharmacokinetics and pharmacodynamics of drugs, and thereby the dose requirement, may be altered by disease. Recognition of these effects is important to avoid undesirable overdosage or underdosage.

We have had the impression for some time that the opioid requirement during anaesthesia is higher in patients with Crohn's disease than in other patients who undergo similar operations. Consequently, we compared the dose requirement of alfentanil in patients with Crohn's disease with that in a control group of patients during elective abdominal surgery.

Methods

Twenty patients (ASA grade 1 or 2) were studied during elective abdominal surgery. Thirteen patients had histologically and/or radiologically proven Crohn's disease and seven other patients without Crohn's disease served as a control group. All patients had normal renal and hepatic function. The study was approved by the Committee on Medical Ethics of the University of Leiden. Informed consent was obtained from all patients.

The patients were premedicated with oral diazepam 0.15 mg/kg about 2 hours before, and intramuscular atropine 0.5 mg 30 minutes before, induction of anaesthesia. A venous blood sample was obtained immediately before induction of anaesthesia for determination of the plasma α_1 -acid glycoprotein (AAG) concentration. Plasma was

separated from blood and stored at -20°C until assayed. AAG plasma concentrations were determined by radio-immunodiffusion.¹

Each patient breathed 100% oxygen for 2 minutes, and anaesthesia was induced with alfentanil 100 $\mu\text{g/kg}$ given over 30 seconds, and thiopentone 2–5 mg/kg. Suxamethonium 1 mg/kg was given to facilitate intubation of the trachea. Immediately after the induction dose of alfentanil, a continuous infusion of alfentanil 50 $\mu\text{g/kg/hour}$ was started, using an infusion pump.

Pancuronium 50 $\mu\text{g/kg}$ was given after tracheal intubation and the lungs were ventilated with 66% nitrous oxide in oxygen. Ventilation was adjusted to maintain an end-tidal carbon dioxide concentration between 4 and 4.5 volumes percent for the entire operation. Only minimal additional doses of pancuronium necessary for surgery were given so that somatic responses could be identified. The electrocardiogram was displayed continuously and arterial pressure was measured and recorded automatically every 3 minutes.

An internal jugular vein was cannulated for measurement of central venous pressure. Nasopharyngeal temperature, urine production and blood loss were recorded every 15 minutes. Fluid losses were replaced by saline or whole blood, as indicated, to maintain the central venous pressure between 8 and 10 mmHg.

The infusion rate of alfentanil was adjusted to maintain adequate anaesthesia. The occurrence of one of the

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Table 1. Patient data: patients with Crohn's disease.

Patient	Age (years)	Weight (kg)	Sex	Surgery*	Duration of surgery (minutes)	Blood loss (ml)
1	31	50	F	C	165	1000
2	32	61	F	ADH	115	100
3	27	47	M	SBR	142	1400
4	42	77	M	C	281	1300
5	33	55	F	IL	153	1700
6	26	61	F	IL	139	600
7	17	55	F	ADH	197	850
8	45	55	M	C	108	2300
9	34	54	F	SBR	100	200
10	24	68	M	IL	122	665
11	31	55	F	ADH	208	1000
12	36	68	F	SBR	150	1000
13	27	58	F	IL	134	510
Median	31	55	—	—	142	1000

*C, colectomy; ADH, adhesiotomy; SBR, small bowel resection; IL, ileocaecal resection.

Table 2. Patient data: control patients.

Patient	Age (years)	Weight (kg)	Sex	Surgery*	Duration of surgery (minutes)	Blood loss (ml)
1	21	62	M	PC	337	2000
2	47	85	F	C	137	1400
3	20	60	M	PC	373	2000
4	38	81	F	SBR	79	100
5	46	50	F	S	209	900
6	30	61	F	ADH	69	200
7	43	66	M	HSV	81	150
Median	38	62	—	—	137	900

*PC, proctocolectomy; C, colectomy; ADH, adhesiotomy; SBR, small bowel resection; S, sigmoidectomy; HSV, highly selective vagotomy.

Table 3. Incidence of responses during anaesthesia. Data are presented as the median (range) number of response episodes per patient. Total response episodes = the total number of responses per patient. More than one type of response that occurred at the same time was counted as one response episode.

	Crohn's	Control
Total response episodes	.6 (3-14)	7 (1-23)
Haemodynamic responses		
SAP* > normal + 15 mmHg	3 (0-9)	4 (1-8)
Heart rate > 90 beats/minute	4 (1-12)	1 (0-18)
Somatic responses	1 (0-14)	2 (0-7)
Other autonomic responses	1 (0-7)	

*SAP, systolic arterial pressure.

following responses to surgical stimuli was taken as an indication of inadequate anaesthesia: 2 increase of systolic arterial pressure greater than 15 mmHg above 'normal' ('normal' systolic blood pressure was defined as the average of three measurements made at the time of admission to the hospital, on the morning of surgery before premedication and just before induction of anaesthesia); a heart rate greater than 90 beats/minute in the absence of hypovolaemia; somatic responses (swallowing, coughing, eye opening or body movements); other autonomic signs of inadequate anaesthesia such as

lacrimation, flushing or sweating. If a response occurred, alfentanil 10 µg/kg was given as a bolus and the infusion rate was increased by 25 µg/kg/hour to a maximum rate of 200 µg/kg/hour. If a patient did not respond during a 15-minute period the alfentanil infusion rate was decreased by 25 µg/kg/hour to a minimum rate of 25 µg/kg/hour.

The alfentanil infusion was discontinued 10 minutes before the anticipated end of surgery and nitrous oxide administration was stopped at the end of the operation. The residual muscle relaxation was reversed by neostigmine 1 mg. The trachea was extubated if the tidal volume was greater than 7 ml/kg, the respiratory rate above 10 breaths/minute and the end-tidal carbon dioxide below 6.5%. If a patient did not regain adequate ventilation within 10 minutes after discontinuation of nitrous oxide, naloxone 0.04 mg was administered intravenously every 1-2 minutes until adequate spontaneous ventilation was established.

The incidences of responses that indicated inadequate anaesthesia in the two groups were analysed by Fisher's Exact Test.

The alfentanil requirement in µg/kg/minute (excluding the initial bolus dose) was calculated for each patient. Spearman rank correlation coefficients were calculated to assess possible relationships between the alfentanil requirement and the duration of the alfentanil infusion and alfentanil requirement and plasma AAG concentrations within each patient group. Differences in the alfentanil requirements, the plasma AAG concentrations and the blood loss between the groups were evaluated with the Mann-Whitney U test. Differences were considered statistically significant if p < 0.05. Values are presented as median unless specified otherwise.

Results

Details of the patients are listed in Tables 1 and 2. The two groups were comparable with respect to age, weight, sex, types and duration of surgery, and blood loss. Four of the 13 patients with Crohn's disease were receiving salazopyrine medication pre-operatively, and seven of the 13 patients were receiving corticosteroids. Patients with Crohn's disease had a higher heart rate before surgery (82 beats/minute) than control patients (70 beats/minute).

The incidences of haemodynamic, somatic and other autonomic responses to noxious surgical stimuli in the two groups are shown in Table 3. Frequently, more than one type of response occurred at the same time. The incidences of each of the responses that indicated inadequate anaesthesia were similar in both groups.

Tables 4 and 5 show the durations of infusion, alfentanil requirements and plasma AAG concentrations in patients with Crohn's disease and control patients respectively. The duration of alfentanil administration in the patients with Crohn's disease did not differ significantly from that in the control group. The alfentanil requirement within each group was independent of the duration of alfentanil administration. The alfentanil requirement in patients with Crohn's disease was significantly higher than in control patients (p = 0.02). A plasma AAG concentration could be determined in 18 of the 20 patients. The plasma AAG concentrations in patients with Crohn's disease were significantly higher than those in the control patients (p < 0.02). However, there was no correlation between

Table 4. Duration of alfentanil infusion, alfentanil requirement and plasma concentration of AAG in patients with Crohn's disease.

Patient	Duration of infusion (minutes)	Alfentanil requirement (µg/kg/minute)	AAG (g/litre)
1	178	1.16	1.58
2	82	0.96	—
3	153	1.19	0.83
4	283	2.59	0.84
5	172	2.71	1.24
6	156	3.89	0.93
7	210	2.74	0.38
8	135	1.85	1.50
9	114	2.14	0.62
10	151	1.03	1.17
11	215	2.85	1.29
12	163	3.42	0.63
13	157	0.77	0.73
Median	157	2.14	0.89

Table 5. Duration of alfentanil infusion, alfentanil requirement and plasma concentration of AAG in control patients.

Patient	Duration of infusion (minutes)	Alfentanil requirement (µg/kg/minute)	AAG (g/litre)
1	383	0.61	0.40
2	181	1.13	0.82
3	427	1.35	0.44
4	88	0.59	0.70
5	224	0.86	0.38
6	86	0.69	0.51
7	103	2.15	—
Median	181	0.86	0.48

plasma AAG concentrations and alfentanil requirement within either group.

Eighteen patients regained spontaneous ventilation within 10 minutes of discontinuation of nitrous oxide at the end of the operation. Naloxone was administered to one patient with Crohn's disease (0.04 mg) and one patient in the control group (0.12 mg) before tracheal extubation.

Discussion

The present study demonstrates an increased dose requirement of alfentanil, given as a supplement to nitrous oxide–oxygen anaesthesia, in patients with Crohn's disease compared with a control group of patients who underwent similar surgery.

The clinical criteria upon which the administration of alfentanil was based included a heart rate that exceeded 90 beats/minute. The fact that the resting heart rate was higher in the group of patients with Crohn's disease might have led to relative overdosage of alfentanil in these patients if additional doses of alfentanil had been given predominantly as a result of an elevated heart rate. However, there was no difference between the groups in this or any other of the criteria used to define inadequate anaesthesia. Furthermore, if relative overdosage due to this cause had occurred in the patients with Crohn's disease, this should have been reflected in a higher incidence of respiratory depression at the end of surgery and consequently a higher requirement for naloxone. This was not the case.

The increased requirement for alfentanil in patients with Crohn's disease may be explained by both pharmacokinetic and pharmacodynamic factors. Theoretically, a larger

volume of distribution and a higher total plasma clearance in patients with Crohn's disease could result in an increased alfentanil dose requirement. Unfortunately, plasma concentrations of alfentanil were not measured in this study.

AAG (or orosomucoid) is the major binding protein for alfentanil.³ AAG plasma concentrations are increased in some diseases characterised by chronic inflammation, such as Crohn's disease.^{4,5} AAG plasma concentrations were higher in patients with Crohn's disease in this study. Therefore, protein-binding of alfentanil would be expected to be higher in patients with Crohn's disease than in control patients. Increased binding has been described for propranolol and chlorpromazine; like alfentanil, these are basic drugs that bind avidly to AAG.^{6,7} A higher protein-binding would result in a decreased free fraction of alfentanil. Drug effect is believed to be related to the free plasma concentration of a drug; thus, this decreased free fraction would be expected to result in less drug effect for a given dose. If this were true, a correlation would be expected between plasma AAG concentrations and alfentanil dose requirement in patients with Crohn's disease. No such correlation was found in this study. It is possible, however, that this correlation between plasma AAG concentrations and alfentanil requirement may have been complicated by other factors such as concurrent medication. Several of the patients with Crohn's disease received salazopyrine and corticosteroids pre-operatively. We are not aware of any studies that have documented the influence of these drugs on either the pharmacokinetics or pharmacodynamics of alfentanil.

Alternatively, the altered dose-response relationship of alfentanil in patients with Crohn's disease may be explained by a change in pharmacodynamics. Patients with Crohn's disease might be less sensitive than control patients to the analgesic effects of alfentanil.

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Comparison of the effects of famotidine and ranitidine on gastric secretion in patients undergoing elective surgery

F. ESCOLANO, J. CASTAÑO, N. PARES, E. BISBE AND J. MONTERDE

Summary

A randomised double-blind comparison of oral famotidine and ranitidine given 2 hours before induction, on gastric secretion (volume and pH) was carried out on 93 patients undergoing elective surgery. Gastric contents were aspirated immediately after tracheal intubation. Famotidine significantly reduced the gastric volume, compared with the other groups, including ranitidine. Both famotidine and ranitidine significantly elevated gastric pH towards neutral, compared with the other groups. There was no significant difference between ranitidine and famotidine in respect of the pH. The patients premedicated with famotidine and ranitidine were well protected against Mendelson's syndrome, whereas 38% of patients from the other groups remained at risk.

Key words

Gastrointestinal tract, stomach; ranitidine, famotidine. Complications; aspiration.

Aspiration of acid stomach contents is a major cause of anaesthetic mortality and morbidity.¹ In 1946, Mendelson² described an acid aspiration syndrome in obstetric patients and suggested the possible benefit of using antacid drugs as a prophylactic measure. In 1974, Roberts and Shirley³ described those patients with a pH of gastric contents <2.5 and a volume >0.4 ml/kg, as at risk of developing Mendelson's syndrome. In 1984, James *et al.*⁴ demonstrated in rats that a gastric content volume of <0.4 ml/kg, together with a gastric pH < 1.0 was lethal in 90% of cases when instilled into the lungs. However, a pH > 1.8 resulted in a significantly lower mortality, even in the presence of gastric volumes greater than 2 ml/kg. Consequently, it seems that a critical volume which would determine the risk of severe aspiration pneumonia does not exist and that the main factor that determines the risk of aspiration pneumonia would be the pH of the aspirate.

The purpose of this present study was to evaluate the effects of prophylactic oral famotidine and ranitidine in patients who undergo elective surgery. Famotidine is a new histamine H₂-receptor antagonist, more potent and with less side effects than previous antagonists.⁵

Methods

The study included 93 patients (48 females) with a mean

age 54.2 years (range 15–85), in ASA classes 1–3, undergoing general anaesthesia for elective surgery; 19.3% of patients were heavy smokers. The study was approved by the clinical investigation committee of our University hospital. Patients with hepatic, renal or gastrointestinal disease, who were pregnant, had a known sensitivity to H₂-receptor antagonists or who were receiving antacids were not studied.

The study was carried out in a double-blind manner. The patients, who were fasted overnight, were randomly allocated to one of four groups. Group 1 (21 patients) did not receive any premedication or antacid therapy. Group 2 (27 patients) were given diazepam 5 mg orally, but no antacid therapy, while Group 3 (21 patients) received diazepam 5 mg and ranitidine 150 mg by mouth. Group 4 (24 patients) were given diazepam 5 mg and famotidine 40 mg. All drugs were given with 20 ml of water 2 hours before surgery.

Anaesthesia was induced in all patients with thiopentone followed by pancuronium, and after 3 minutes of manual ventilation of the lungs with 100% oxygen, the trachea was intubated; anaesthesia was maintained with 70% nitrous oxide in oxygen supplemented with volatile agents or opioids. Anticholinergic agents were avoided until the sample had been obtained. Immediately after induction, once the patient had settled down, a size 18 nasogastric tube was inserted into the stomach and its correct position checked by auscultation of injected air. The gastric contents

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Table 1. Demographic data. Values expressed as mean (SEM).

Patient groups	Age (years)	Weight (kg)	Height (cm)
1. No premedication	55.2 (4.4)	68.9 (2.0)	164.3 (1.5)
2. Diazepam	49.4 (3.7)	68.0 (1.6)	167.4 (1.4)
3. Ranitidine	56.2 (3.5)	67.4 (2.4)	162.7 (1.8)
4. Famotidine	56.0 (3.4)	67.6 (3.0)	165.2 (2.0)

Table 2. Patients with zero volume extraction.

Patient groups	Patients (n)	Patients with zero volume	p
No premedication	21	0	0.56
as compared with diazepam	27	1	
No premedication	21	0	0.10
as compared with ranitidine	21	4	
No premedication	21	0	0.03
as compared with famotidine	24	6	
Diazepam as compared with	27	1	0.21
ranitidine	21	4	
Diazepam as compared with	27	1	0.07
famotidine	24	6	
Ranitidine as compared with	21	4	0.90
famotidine	24	6	

Table 3. pH and volume values for the four groups. Values expressed as mean (SEM).

Groups	Volume	pH	Patients (n)
No premedication	26.6 (4.9)	2.8 (0.5)	21
Diazepam	27.7 (4.9)	2.7 (0.4)	26
Ranitidine	8.9 (1.3)	7.0 (0.3)	17
Famotidine	5.4 (1.0)	7.4 (0.1)	18

Table 4. Statistical analysis of the results shown in Table 3.

Patient groups	Volume		pH	
	Value U	Significance	Value U	Significance
No premedication as compared with diazepam	257.5	p > 0.05	246.5	p > 0.05
No premedication as compared with ranitidine	69.5	p < 0.01	36.5	p < 0.01
No premedication as compared with famotidine	38	p < 0.01	28	p < 0.01
Diazepam as compared with ranitidine	87	p < 0.01	16	p < 0.01
Diazepam as compared with famotidine	52.5	p < 0.01	10	p < 0.01
Ranitidine as compared with famotidine	91.5	p < 0.05	121	p > 0.05

were then aspirated and the volume and pH measured. The samples were divided into two for measurement of pH, one by the Department of Pharmacy and the other the Department of Biochemistry. The pH was measured by a pH micro-electrode Crison (ref. 104023414) attached to a digital pH metre Microph Crison (ref. 2001).

Table 5. Patients at risk of developing Mendelson's syndrome.

	Group 1 (n = 21)	Group 2 (n = 26)	Group 3 (n = 17)	Group 4 (n = 18)
Patients with pH < 2.5	14 (66.7%)	19 (73.0%)	0	0
Patients with volume > 25 ml	10 (47.6%)	11 (42.1%)	0	0
Patients with pH < 2.5 and volume > 25 ml	8 (38.1%)	10 (38.5%)	0	0

None of the patients premedicated either with famotidine or ranitidine were at risk of developing Mendelson's syndrome. About 38% of patients premedicated only with diazepam or nothing presented such a risk.

Statistical analysis

Demographic data (age, weight and height) were compared using the unpaired *t*-test. The Bonferoni correction was used to determine the level of significance since six comparisons were made in the study. Thus the usual level of significance (0.05) is divided by the number of comparisons (six in this case) giving a value of 0.0083, which is then taken as the level of significance. The time of drug administration to sampling varied from 1–4 hours, so a correlation coefficient was obtained that related time, volume and pH. The paired Student's *t*-test was used to compare the data obtained separately from each laboratory. The Fisher exact probability test was used to evaluate the statistical significance of those patients whose aspirated volume was zero. For the comparison of pH and volume values in the four groups, the Kruskal–Wallis test was used, and the results were further analysed by the Mann–Whitney *U* test.

Results

The four groups of patients were comparable with respect to age, weight and height (Table 1). There was no significant difference between pH and volume values with regard to the time elapsed from drug administration to sample extraction, except time versus pH in the ranitidine group. The results obtained from the two different laboratories were not significantly different.

Comparison of patients with zero volume extraction (Table 2) showed no significant difference in, or between, groups, except that of famotidine patients compared to non-premedicated patients.

Table 3 shows the pH and volume values obtained for each group, and the statistical evaluation of these results are shown in Table 4. The volume obtained in those given famotidine was significantly lower than any of the other groups, including ranitidine. The mean pH values approached neutral in both the ranitidine and famotidine groups; the differences were significantly different from the other two groups. There was no significant difference between the pH values of the famotidine and ranitidine patients. There was also no significant difference between the results obtained in the patients premedicated only with diazepam compared to the nonpremedicated patients.

None of the patients who received ranitidine or famotidine were at risk according to the criteria of Roberts and Shirley³ (Table 5), compared to 38% of those who received no premedication or diazepam only.

Discussion

The extent of pulmonary lesions following aspiration of gastric contents depends mainly on the acidity of the aspirate,⁴ but a high residual gastric volume may lead to regurgitation and aspiration.⁶ It is generally accepted that patients with a gastric volume > 25 ml and a pH < 2.5 at the moment of induction, are at risk of acid aspiration pneumonia.³ Risk factors include obesity,⁷ where 77% have a gastric volume higher than 25 ml and a pH lower than 2.5; late pregnancy;⁸ children;⁹ outpatients¹⁰ and those presenting for emergency surgery.^{11,12} In order to decrease this risk, it is necessary to raise the intragastric pH and decrease the volume of the gastric contents. A number of methods have been used to achieve these effects. Oral antacid emulsions such as magnesium trisilicate or aluminium trisilicate raise pH values but they are not free from side effects, such as pulmonary lesions due to aspiration of antacid particles;^{13,14} they also increase intragastric volume.¹⁴ There is only a transitory decrease in P_{aO_2} following aspiration of gastric contents buffered with nonparticulate antacids such as sodium citrate or sodium bicarbonate.^{15,16} However, CO_2 is produced by interaction with gastric acid and gastric volume is therefore increased with an increased chance of aspiration.⁸

Metoclopramide decreases intragastric volume, but has no effect on the pH.^{6,17} It also has a number of side effects.¹⁸

The histamine H_2 -receptor antagonists cimetidine and ranitidine produce an effective decrease of the gastric acidity,^{19,20} but there is some controversy about their effects on intragastric volume.^{21,22} The reason for this could be technical problems with aspiration of the nasogastric tube that may not be correctly positioned, or failure to empty the stomach completely at each attempt.

Ranitidine and cimetidine must be given 45 minutes before surgery if used intravenously.^{20,23} Both drugs influence other drugs' elimination. Cimetidine interferes with the oxidative metabolism of other drugs via the cytochrome P450 system and reduces the elimination of oral anticoagulants,²⁴ propranolol,²⁵ benzodiazepines²⁶ and theophylline.²⁷ Bradycardia and asystole might follow rapid infusion of cimetidine.^{27,28} Ranitidine is more potent and longer acting than cimetidine and associated with fewer drug interactions.^{19,29}

Famotidine is a new histamine H_2 -receptor antagonist. Its pharmacological effects have been reviewed by Campoli et al.⁵ It has a potency 20 times that of cimetidine and 7.5 times that of ranitidine. Plasma concentrations reach a peak 1–3.5 hours after administration when administered orally. The relationship is dose-dependent. A plasma concentration of 13 $\mu\text{g/litre}$ results in 50% gastric acid inhibition. A single dose of famotidine 40 mg orally results in a plasma concentration greater than 13 $\mu\text{g/litre}$ for more than 12 hours, whereas a dose of 20 mg results in plasma concentrations greater than this for 7 to 9 hours. Famotidine is 15–22% bound to plasma proteins and excreted mainly unchanged by the kidneys. A small fraction is metabolised to famotidine sulfoxide before renal elimination; the biological activity of this metabolite is unknown. It has fewer drug interactions than cimetidine and ranitidine, although theoretically it could increase the sedative effect of midazolam. Side effects are few, but include constipation, diarrhoea, headache, tinnitus, cutaneous rashes.

Our results are similar to those obtained by Merki et al.³⁰ in healthy volunteers. Famotidine reduces significantly the volume of gastric secretion compared to ranitidine. Both ranitidine and famotidine produce a similar elevation of pH to levels approximating neutrality. No side effects were found with either drug in the doses used in this study. All patients who received famotidine or ranitidine were protected from the development of Mendelson's syndrome according to accepted criteria.

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Effect of vecuronium on atropine-induced changes in heart rate

S. RIDLEY, D. G. GAYLARD AND M. LIM

Summary

The effect of vecuronium on the heart rate response to atropine has been studied by comparing dose-response relationships in two groups of patients who underwent extracorporeal shock wave lithotripsy. One group received vecuronium (0.1 mg/kg) and the other acted as control. Incremental doses of atropine (1.8, 1.8, 3.6, 7.2 and 14.4 µg/kg) were administered and changes in heart rate recorded. No significant differences were observed between the two groups following each incremental dose of atropine.

Key words

*Neuromuscular relaxants; vecuronium.
Heart; arrhythmia, bradycardia.*

Vecuronium is generally considered to have no significant cardiovascular effects, although a number of instances of bradyarrhythmia have been associated with its use.^{1–6} It has been suggested that these bradyarrhythmias are the passive manifestation of a predominance in vagal tone induced by either mechanical stimulation (e.g. peritoneal traction) or other drugs, because vecuronium is relatively devoid of any vagolytic or sympathomimetic effects. However, a recent study⁷ suggested that vecuronium may have a direct causative role in producing a bradycardia which is most pronounced when the drug is used in combination with etomidate and fentanyl. The aetiology of such a primary effect of vecuronium remains unclear but a possible mechanism is an increase in vagal tone induced either directly or indirectly as a result of a sympatholytic effect. A possible method of demonstrating such an increase in vagal tone is to examine the heart rate response to atropine. We present the results of a study in which the dose-response relationships of atropine in patients who received vecuronium were compared with those in a control group.

Methods

The study was conducted on patients who underwent extracorporeal shock-wave lithotripsy (ESWL). During ESWL the discharge of the electrode is triggered by the R wave of the electrocardiogram (ECG) in order to minimise the occurrence of arrhythmias. Atropine is administered routinely to fit patients in our unit to produce an increase

in heart rate, so that the duration of treatment is reduced. Local ethics committee approval was obtained to investigate atropine dose-response relationships on a selected group of these patients.

Twenty patients (ASA grade 1) aged between 20 and 40 years were allocated randomly to receive vecuronium or to act as control. Patients who were receiving drugs that might affect heart rate were excluded. Informed consent was obtained from all patients. No premedication was given. Anaesthesia was induced in all patients with midazolam (0.7 mg/kg), fentanyl (1.5 µg/kg) and thiopentone (3–4 mg/kg). The trachea was intubated after administration of suxamethonium (1 mg/kg) and topical administration of lignocaine (4 ml of 4% solution) to the larynx, and anaesthesia was maintained with oxygen (33%), nitrous oxide (67%) and enflurane (0.5%). Intermittent positive pressure ventilation was performed with a Manley ventilator using minute and tidal volumes of 85 ml/kg and 7 ml/kg respectively. Arterial pressure was recorded at 3-minute intervals using a Dinamap automatic recorder. Patients in the treatment group received vecuronium 0.1 mg/kg 10 minutes after tracheal intubation. In all patients, a 30-second baseline ECG was recorded 12 minutes after tracheal intubation. All patients then received the following incremental doses of atropine: 1.8, 1.8, 3.6, 7.2, 14.4 µg/kg. These doses were selected to facilitate the plotting of log dose-response relationships; the total dose of atropine was 2.0 mg in a 70-kg individual. Each dose was diluted with physiological saline to a volume of 2 ml and administered over 5 seconds at 2-minute in-

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Table 1. Age, weight and baseline heart rate expressed as mean (SD).

	Vecuronium <i>n</i> = 10	Control <i>n</i> = 9
Age, years	31.4 (5.7)	31.8 (4.6)
Weight, kg	71.7 (17.7)	67.6 (15.5)
Heart rate, beats/minute	77.7 (4.6)	79.8 (9.9)
Male/female	5/5	4/5

Table 2. Heart rate changes (beats/minute) after each dose of atropine. Data are expressed as mean (SD).

Cumulative dose µg/kg	Vecuronium	Control
1.8	−4.3 (2.9)	−1.8 (2.77)
3.6	−3.6 (5.5)	−4.2 (3.27)
7.2	4.4 (6.1)	3.1 (6.2)
14.4	14.6 (6.0)	17.4 (5.2)
28.8	21.7 (7.1)	25.4 (6.9)

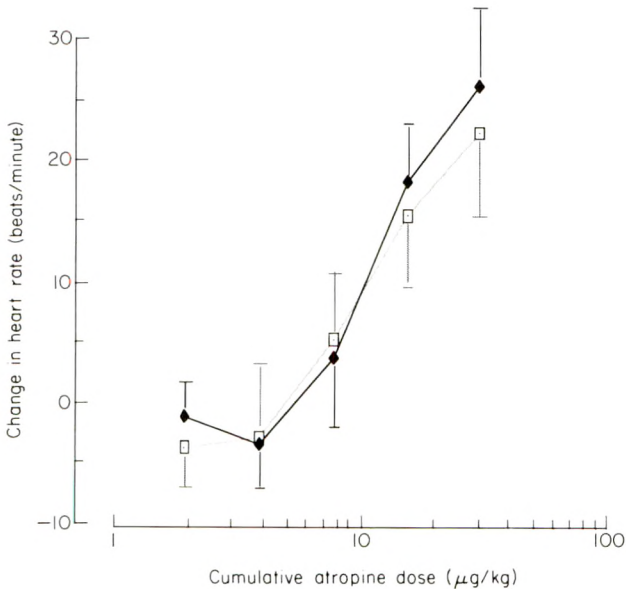


Fig. 1. Log dose-response relationships for vecuronium (□) and control groups (◆). Values shown are mean; bars indicate SD.

tervals. The ECG was recorded continuously until 2 minutes after the final dose. Patients in the control group were given vecuronium 0.1 mg/kg after the study period and all patients then underwent treatment in the normal fashion. All patients were followed up in the recovery period to detect signs of central atropine toxicity. Change in heart rate was plotted against cumulative atropine dose on a logarithmic scale and results analysed using unpaired *t*-tests.

Results

Patients in the two groups were comparable with regard to age, weight, sex distribution and control heart rates (Table 1). One patient in the control group coughed during the test period and his results were excluded from analysis. The changes in heart rate after each atropine dose are shown in Table 2. Log dose-response relationships for both groups are shown in Figure 1. No significant differences in heart rate responses were detected between the groups. No signs

of central atropine toxicity were detected in any of the patients. Five patients in the vecuronium group and three in the control group developed an arrhythmia during the study. The arrhythmias comprised either junctional rhythm or atrial ectopic beats; they were of short duration and always ended spontaneously.

Discussion

The bradyarrhythmias associated with the use of vecuronium are a cause for concern. These events have been ascribed to mechanically-induced vagal stimulation,^{2,3,8} or the revealed effects of other components of the anaesthetic technique in the absence of compensatory vagolytic or sympathomimetic side effects of muscle relaxants such as pancuronium.⁹

The authors of a recent study⁷ suggested that vecuronium has a direct bradycardic effect which is more pronounced when it is used in association with etomidate than with thiopentone, and is augmented by the addition of fentanyl. The aetiology of such an effect is unclear, but a possible mechanism is an overall increase in vagal tone produced either by direct vagal stimulation or by a decrease in sympathetic tone.

Atropine is a competitive muscarinic receptor antagonist which produces changes in heart rate.¹⁰ If vecuronium causes an increase in vagal tone, it might be expected that it should produce a change in the heart rate response to atropine. The present study demonstrated no significant difference between the dose-response relationships for atropine-induced tachycardia in the two groups of patients studied. This suggests that the addition of vecuronium to an anaesthetic regimen that incorporates fentanyl does not induce directly an overall increase in vagal tone.

It is possible that a bradycardic effect of vecuronium may be apparent only in the presence of etomidate or when large doses of opioids are used in conjunction with vecuronium. However, a small but significant slowing of heart rate was demonstrated by Inoue *et al.*⁷ when vecuronium was used in conjunction with small doses of fentanyl in the absence of etomidate. In addition, there have been case reports of bradycardias with vecuronium and opioids in the absence of etomidate.^{1–3} Thus a significant increase in vagal tone should have been demonstrated in our study if this is the cause of vecuronium-induced bradycardia.

The time interval between the administration of vecuronium and the test period may influence the results. It has been suggested by Inoue *et al.*⁷ that the bradycardic effect may become apparent only 11–12 minutes after administration of the agent. However, that time interval in their study included the period of intubation, the haemodynamic effects of which may have masked any immediate effects of vecuronium. Furthermore, there have been reports of bradycardia that occurred immediately after the administration of vecuronium.^{4,8} In the present study, observations were continued for 12 minutes after administration of vecuronium, and should have demonstrated either an early or late change in vagal tone.

In conclusion, we have failed to demonstrate that the addition of vecuronium to an anaesthetic technique that included fentanyl produces a significant effect on the heart rate response to atropine. This suggests that vecuronium does not induce a significant increase in vagal tone.

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CASE REPORT

Penetrating craniocerebral airgun injury

Anaesthetic management with propofol infusion and review of recent reports

P. J. WRIGHT AND R. J. MURRAY

Summary

Low velocity cerebral missile injuries inflicted by air guns frequently cause little primary neurological damage, but the patient often suffers severe later deterioration which has been classified as a type of 'talk and die' head injury. The anaesthetic management of a penetrating air rifle missile injury using an infusion of propofol is described.

Key words

Complications; trauma.

Total intravenous anaesthesia with propofol has been shown to reduce cerebral blood flow and oxygen metabolism,¹ and has been successfully used in patients who have elective neurosurgery.² We report its use in the anaesthetic management of a penetrating craniocerebral missile injury.

Case history

A 15-year-old 60 kg male was accidentally shot at a range of one metre by a 5.5-mm calibre B.S.A. Airsporter air rifle, and sustained a small but bloody temporal laceration. The patient was taken to the receiving hospital and complained of nausea and feeling faint, but he did not lose consciousness at any time. The casualty officer found no neurological deficit, and performed debridement and primary suture of the scalp wound. No pellet was found so skull X rays were ordered which revealed a punctate pterion fracture and an underlying intracranial foreign body with the characteristic shape of an air rifle pellet (Figs 1 and 2). The patient was transferred to a general surgical ward for overnight observation and intravenous fluid and antibiotic therapy. He suffered two focal epileptic fits during the night and was treated with intravenous phenytoin. A CAT scan the next morning showed an intracranial haematoma (Fig. 3), a pterion fracture with an underlying depressed bone fragment, and a clearly defined downward missile track in the temporal lobe (Fig. 4). The pellet was identified in the deeper portion of the temporal lobe and had not crossed the midline. The patient was immediately transferred to the neurosurgical unit for an urgent craniotomy.

He was alert, cooperative and had stopped fitting on arrival in the anaesthetic room. Anaesthesia was induced after pre-oxygenation and maintained with an infusion of propofol using the manually controlled scheme described by Roberts and his colleagues.³ This aims to produce a blood propofol concentration of 3 µg/ml by a loading dose of propofol and three successive infusion rates. The propofol was supplemented with 67% nitrous oxide.



Fig. 1. Lateral skull X ray that shows pterion fracture (arrowed).

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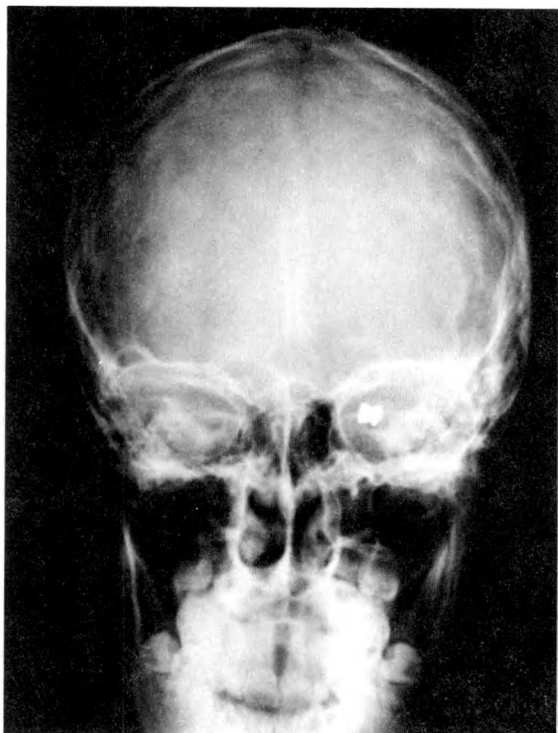


Fig. 2. Posterior-anterior skull X ray that demonstrates deformed intracranial air rifle pellet.

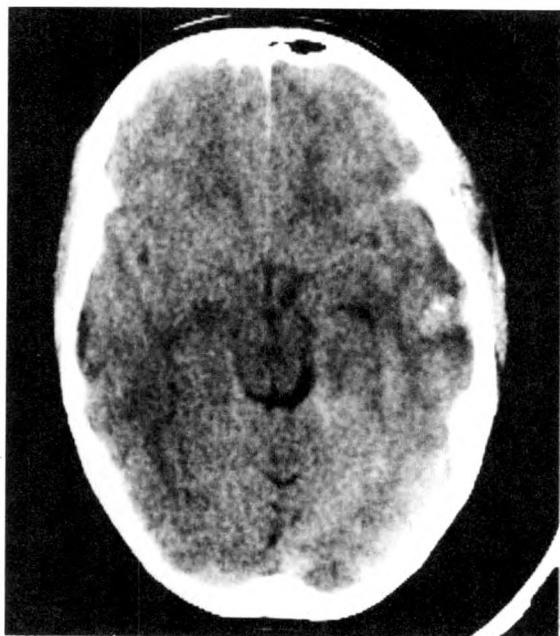


Fig. 3. CAT scan of head that shows intracerebral haematoma.

Atracurium 40 mg was given to facilitate tracheal intubation, preceded by fentanyl 125 μ g to attenuate reflex laryngeal responses. Neuromuscular blockade was maintained using a continuous infusion of atracurium given at the rate required to obtain a train-of-four suppression ratio of 0.9. The following variables were continuously monitored: direct arterial pressure using the left radial artery, central venous pressure (CVP) through the right internal jugular vein, electrocardiogram and end-tidal carbon dioxide partial pressure ($PE'CO_2$). Separate infusions



Fig. 4. Lower slice, same scan, that shows indriven bone and missile track in the temporal lobe.

were employed for each anaesthetic drug, pressure monitoring and fluid replacement. The patient lost consciousness within 2 minutes of starting the propofol infusion, with no change in systemic arterial pressure or CVP. There was an increase in systolic arterial blood pressure of 15 mmHg during tracheal intubation.

Surgical treatment began with debridement of the entry wound and reclosure. A pterion craniotomy was performed that revealed a ragged dural tear with underlying cerebral haematoma and localised cerebral oedema. The brain was found to be slack and operating conditions were judged to be good by the operating team. The spicule of indriven bone was removed together with the blood clot and dead cerebral tissue. The edges of the pellet track were cleaned and the pellet removed from the base of the temporal lobe. Ventilation was controlled throughout the 4-hour procedure to maintain a $PE'CO_2$ within the range of 3.8–4.0 kPa. Cardiovascular parameters were stable during the operation with only minor elevations of arterial pressure in response to surgical stimulation. Towards the end of the procedure intravenous labetalol 40 mg was given in 10 mg increments to keep the arterial blood pressure within pre-operative limits. The atracurium infusion was stopped 5 minutes before the end of the operation, and the propofol infusion after the last skin suture. The patient began to breathe spontaneously with reversal of neuromuscular blockade. Consciousness was regained 3 minutes after termination of the propofol infusion and at 5 minutes the patient was fully alert. The postoperative course was uneventful and the patient made a complete recovery. He was discharged home with prophylactic oral phenytoin.

Discussion

The delay in patient diagnosis and referral for definitive neurosurgical treatment illustrates that air gun wounds are generally regarded as trivial injuries. However, there is overwhelming evidence that craniocerebral wounds must be treated with the utmost urgency and care. In 20 cases of head injury inflicted by air guns, five deaths and four

patients with severe residual disablement have been reported.⁴⁻¹³ These injuries are more common in children with thin skulls, but air rifles in common use are capable of generating the impact velocity of 107 m/second necessary to penetrate an adult skull with fatal results.^{6,14} The low velocity missile gives up much of its energy on impact and primary neurological damage may be minimal unless large vessels or vital structures such as the brain stem are involved.

Cerebral haemorrhage is a consistent finding and can occur even with non-penetrating injuries.^{9,13} Less common sequelae include early epilepsy,^{8,13} meningitis,⁷ hydrocephalus,¹² and where there is muzzle contact pneumocephalus has been observed.¹⁰ Thus the patient often presents with an apparently trivial skin wound and no abnormal neurological signs, yet remains at high risk of developing secondary neurological damage and even death. Cerebral air gun injuries may thus be classified as a type of 'talk and die' head injury.^{8,15} It is clear from the reports referred to above that the management of these injuries should be the same as for conventional gunshot wounds.

The anaesthetic management of gunshot wounds in civilian practice in the UK has been concentrated by experience of the civil disturbances in Northern Ireland.¹⁶⁻¹⁸ Intravenous anaesthesia with thiopentone and neuroleptanaesthesia have been successfully employed in missile injuries where the cerebral vasodilator effects of the volatile agents are a disadvantage.¹⁹ Propofol has recently been shown to have a favourable pharmacological profile for neuroanaesthesia,^{1,2} and has also been used for long periods of sedation on intensive care.²⁰ The cardiovascular stability exhibited during induction with propofol may be a great advantage when it is essential to maintain cerebral perfusion in patients with potentially raised intracranial pressure. In combination with fentanyl, good attenuation of the pressor response to laryngoscopy and intubation has additional advantages for the patient. It is necessary rapidly to achieve a steady blood propofol concentration.³ Any sudden unexplained change in heart rate, blood pressure or CVP under steady state anaesthesia then alerts the anaesthetist to a possible change in the neurophysiological status of the patient. The rapid and clear headed recovery observed after infusion of propofol for prolonged periods enables prompt neurological assessment of the head injured patient in the early recovery period.

In conclusion, craniocerebral missile injuries caused by air guns should be treated with the same degree of urgency and attention to detail as conventional gunshot wounds. Air rifles can maim or kill, and the injuries they inflict on the brain are comparable with low velocity gunshot wounds in civilian practice. The lack of control over these weapons has allowed very large numbers into circulation, and at least one neurosurgical unit has reported them as the commonest cause of penetrating craniocerebral missile injury.⁸ Total intravenous anaesthesia with propofol has been found to provide excellent operating conditions in neurosurgical patients, with marked cardiovascular stability

and early recovery. We recommend propofol infusion for the anaesthetic management of low velocity craniocerebral missile injuries.

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Propofol infusion for sedation of patients with head injury in intensive care

A preliminary report

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Summary

Propofol was given by continuous intravenous infusion to 10 patients with severe head injuries in the intensive care unit. Heart rate, mean arterial blood pressure, intracranial pressure, cerebral perfusion pressure, pupil size and arterial carbon dioxide tension were recorded throughout the study period. A mean infusion rate of 2.88 mg/kg/hour provided satisfactory sedation, and recovery from the propofol was often rapid. Cerebral perfusion pressure was significantly increased at 24 hours.

Key words

*Anaesthetics, intravenous; propofol.
Complications; trauma, head injury.*

Patients with severe head injury in intensive care require sedation as part of the treatment to control intracranial pressure (ICP). Most centres rely on narcotics such as morphine, and benzodiazepines such as midazolam to provide sedation, since the withdrawal of Althesin and etomidate for continuous intravenous infusion.^{1,2} Intravenous anaesthetic agents, for example barbiturates, have been used to prevent or treat sustained high levels of ICP. However, their action is prolonged and neurological assessment is often delayed for several days until the drug is completely excreted.

Propofol is an alkylphenol which has been extensively investigated for use as an anaesthetic agent.^{3,4} It is now prepared as an aqueous soya bean emulsion which has been shown in animals to be unlikely to produce anaphylactoid reactions.^{5–7} It is short acting and rapidly metabolised and therefore a suitable agent for infusion techniques.⁸ Initial work showed that recovery after a loading dose of propofol was rapid,⁹ and when used as an infusion to provide sedation during regional anaesthesia, or as a maintenance anaesthetic agent, there was lack of accumulation and again rapid recovery.¹⁰ A propofol infusion used to provide sedation for up to 8 hours in patients whose lungs were artificially ventilated in a general intensive care unit,¹¹ and after cardiac surgery,¹² was found to be a suitable agent that allowed rapid recovery. There was no evidence of any significant inhibition of adrenal steroidogenesis¹¹ and although fat emulsions have been shown to alter blood coagulability, only a minor increase in prothrombin time was noted.¹¹

The present study was designed to assess the use of propofol infusion for sedation of patients with head injury.

Methods

A clinical trial exemption certificate was obtained from the Committee on Safety of Medicines since propofol is currently only licensed to maintain anaesthesia for up to one hour. Ethics committee approval and informed consent from the patients' next of kin was obtained.

Ten patients, who required sedation as part of their clinical management, were studied. Ages ranged from 16 to 61 years, and no patient was allergic to propofol or had a known adverse reaction to anaesthesia. Cardiovascular instability or possible pregnancy were also considered to be contraindications to inclusion to the study. All patients had a computerised tomography (CT) scan of the skull before admission to the intensive care unit.

Head injured patients admitted to intensive care for ventilation and ICP monitoring were sedated with morphine 5–10 mg and midazolam 5–10 mg and were given vecuronium 0.1 mg/kg/hour by infusion. Ventilation was controlled to maintain P_{aCO_2} at a constant level and hyperventilation instituted if control of ICP was required. The electrocardiogram (ECG) was continuously displayed; systolic and diastolic arterial blood pressure were monitored through a cannula inserted into a radial artery and ICP through an intraventricular catheter or a Richmond bolt.

Patients were admitted to the study after routine baseline clinical examination, that included estimation of

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the Glasgow Coma Scale score,¹³ and baseline measurements. Midazolam was discontinued and morphine only prescribed if analgesia was thought to be required. A propofol infusion, as a 1% solution, was started at a rate of 2–4 mg/kg/ hour through an Imed 800 dual syringe driver. The infusion rate was adjusted throughout the study period to maintain ICP at or below 10 mmHg while maintaining cerebral perfusion pressure (CPP) above 60 mmHg.

The following measurements were made at hourly intervals for the first 4 hours and then at 4-hourly intervals for the remainder of the 24-hour study period: heart rate, systolic and diastolic arterial blood pressures, mean arterial pressure (MAP), ICP, pupil size and arterial carbon dioxide tension (Paco₂). The Hewlett Packard monitoring network with a Careview data management package was used to collect data. This allows for collection of haemodynamic data over a 24-hour period, and provides a graphical representation of these data. Pupil size was measured using a simple pupillometer constructed from a strip of clear flexible perspex in which were drilled holes of known diameter.

The rate of propofol infusion was recorded and administration of other drugs noted. Antibiotics and anticonvulsants were used as indicated, and all patients received ranitidine 50 mg 8 hourly.

A single dose of thiopentone and(or) an infusion of mannitol was given when ICP was not adequately controlled, despite hyperventilation and adequate analgesia. Other interventions which could have been used included cerebrospinal fluid (CSF) drainage, pentobarbitone ‘coma’ and cooling of the patient. Only one patient required a repeat of CT scan and surgery during the study period.

The propofol infusion was discontinued and the patient allowed to recover at the end of 24 hours. However, the vecuronium infusion was continued and sedation provided by morphine and midazolam, if the clinical situation dictated that hyperventilation should be maintained. The total dose of propofol administered to each patient was calculated and cerebral perfusion pressure throughout the study period plotted. This was obtained from the formula CPP= MAP–ICP.

An overall assessment of the quality of sedation and speed of recovery was made by one of the investigators. This was based on the stability of ICP, MAP and CPP and the requirements of any additional sedative agents. Sedation and recovery were graded as either good or poor and comments on the factors which contributed to this assessment were recorded.

Adverse reactions which might have been attributable to propofol were sought and the time to discharge from intensive care, or date of death of the patient noted. In the event of death a postmortem examination report was obtained whenever possible.

Statistical analysis

Data recorded as continuous variables have been summarised in the Tables as means with standard deviations and ranges. Discrete data have been summarised by presenting the number of patients in each category. Student’s *t*-test has been applied to within-group changes from baseline for haemodynamic parameters. Pupil size was analysed by the Sign test. The difference between groups has been considered to be significant at *p* < 0.05.

Results

Demographic details are shown in Table 1. One patient was female. The body weight of the patients was estimated and ranged between 50 and 80 kg. The patients were aged between 16 and 61 years (mean 36.8 years). In general, on admission the patients’ Glasgow Coma scores were low; the majority had total scores of 5 or less (median 4; range 3 to 10).

Eight patients sustained their head injury as a result of a road traffic or other accident. One patient had received a gunshot wound and one resulted from a bomb-blast injury. Eight patients had intracerebral contusions or haematomata and the lungs of two were ventilated postoperatively after surgical removal of a cerebral haematoma. One patient suffered from diabetes and one had angina; otherwise there were no concurrent medical problems.

Three patients did not receive any drugs in the hour before the study period. Two patients had received morphine and three midazolam in the hour before the start of the study. One patient (8) in the latter group also received phenytoin to control convulsions. Other drugs administered in the hour preceding the study are shown in Table 2.

Details of the propofol infusion

In nine patients propofol was administered for 24 hours. In one patient (4) the infusion was stopped after 18.5 hours to allow neurological assessment. The total dose of propofol over the 24-hour study period ranged from 2310 to 9550

Table 1. Patient details and administration of propofol.

Patient	Sex	Age (years)	Weight (kg)	Glasgow Coma Scale on admission	Mean rate of propofol infusion (mg/kg/hour)	Total dose of propofol over 24 hours (mg)
1	F	31	60	3	3.77	5490
2	M	25	70	3	2.13	3570
3	M	21	70	10	2.21	3720
4	M	16	50	5	2.50	2310
5	M	16	50	4	2.27	2720
6	M	48	75	3	1.79	2960
7	M	60	75	8	2.13	3830
8	M	57	60	4	4.03	5800
9	M	33	80	5	4.97	9550
10	M	61	80	4	3.01	5780
Mean		36.8	67	4.9	2.88	4573
SD		18.13	11.35		1.04	300.2

Table 2. Administration of drugs other than muscle relaxants, antibiotics and ranitidine, before and during the study period.

Patient	Drugs administered in hour before study	Drugs administered during study
1	Morphine	Practolol
2	—	Phenytoin, mannitol
3	Midazolam	Morphine, mannitol, fentanyl
4	Midazolam	Midazolam, phenytoin
5	—	Midazolam, phenytoin, mannitol
6	Propofol	Thiopentone, mannitol, phenytoin
7	—	Phenytoin, morphine
8	Phenytoin, midazolam	Phenytoin, midazolam
9	Morphine, mannitol	Morphine, mannitol, frusemide
10	—	—

mg (39.5 to 119.4 mg/kg). The mean rate of administration of propofol based on estimated body weights was 2.88 mg/kg/hour (range 1.79 to 4.97 mg/kg/hour; Table 1).

The propofol infusion was started in the range 2.0 to 3.0 mg/kg/hour in patients 1–6. In the remaining patients a higher starting infusion of 4.0 mg/kg/hour was selected to ensure that higher infusion rates could be used without compromise of arterial pressure and therefore cerebral perfusion pressure.

Administration of other drugs (Table 2)

One patient (6) received a dose of thiopentone 150 mg during sedation and five patients required infusions of mannitol to aid control of ICP. Patient 4, who proved difficult to sedate, received regular doses of midazolam in preference to an increase in the infusion rate of propofol. Other drugs administered during the study period are shown in Table 2.

Patient 3 was taken to the operating theatre for 135 minutes during the study period. In addition to continuing the propofol infusion, anaesthesia was maintained by nitrous oxide, oxygen and fentanyl.

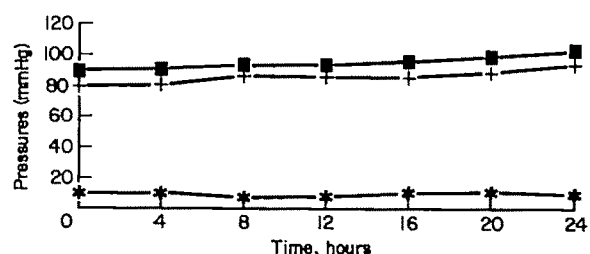
Arterial pressure and heart rate

Overall there were no statistically or clinically significant changes in arterial pressure or heart rate compared to baseline values. The arterial pressure at baseline averaged 128.2/69.8 mmHg (MAP averaged 89.3 mmHg). Minor increases and decreases in systolic, diastolic and MAP occurred during the study period, but in particular, there was no significant hypotension in patients 7–10 who received higher initial infusion rates of propofol.

Intracranial and cerebral perfusion pressure

Baseline ICP after hyperventilation was satisfactory in all but one patient, and ranged between 0 and 35 mmHg (median 5.5 mmHg). It remained above 20 mmHg in patient 1, who had a baseline ICP of 35 mmHg. Similarly, satisfactory baseline values of cerebral perfusion pressure were recorded in most patients (median 77.3 mmHg), and only one patient, 6, had a baseline value below 60 mmHg, as a result of low mean arterial pressure.

No statistically significant increases in ICP occurred, but a slight decrease of 2.1 mmHg at 2 hours achieved statistical significance ($p = 0.049$). Mean perfusion pressure, as seen in Figure 1, generally increased during the later stages of sedation, but the difference was only statistically significant at 24 hours (9.8 mmHg, $p = 0.028$).

**Fig. 1.** Changes of mean arterial pressure, intracranial pressure and cerebral perfusion pressure during the study period, —■—, MAP; —+—, CPP; —*—, ICP.

Pupil size

There were no significant changes in pupil size during sedation, except in patient 9 in whom pupillary dilatation occurred at 16 hours, coincident with an increase in ICP and a decrease in CPP.

Ventilation

All patients were hyperventilated to maintain P_{aCO_2} between 3.0 and 4.5 kPa and therefore there was no change in the partial pressure of CO_2 during sedation.

Quality of sedation (Table 3)

The quality of sedation was considered to be good in nine patients and poor in one (4). This patient received additional doses of midazolam, in preference to an increase in the infusion rate of propofol, which remained at 2.43 mg/kg/hour.

Recovery (Table 3).

The quality of recovery after propofol was recorded in six patients and was judged to be good in four patients and poor in two, both of whom had severe injuries and showed slow return of neurological function.

Recovery was not assessed in four patients. In two of these, (8 and 9), sedation was continued with morphine and midazolam after the end of the 24-hour study period, when the propofol infusion had been stopped. Patient 5 suffered a rapid increase in intracranial pressure from which he eventually died, and patient 10 returned to theatre for maxillofacial surgery.

Outcome

There were no adverse reactions to propofol noted in any of the patients and no patient died while receiving the infusion of propofol. Four patients died subsequently while in intensive care as a result of their injuries and six were transferred to the neurosurgical wards. The number of days from admission to death or transfer is shown in Table 4.

Four of the six patients who were discharged from intensive care were later transferred to the referring hospital, one was discharged home and one died in the neurosurgical ward. The use of propofol was not implicated in the death of any of those patients who did not survive and postmortem examination confirmed that head injury was the cause of death in each case.

Table 3. Quality of sedation and recovery.

Patient	Sedation	Recovery
1	Good	Poor
2	Good	Good
3	Good	—
4	Poor	Good
5	Good	—
6	Good	Poor
7	Good	Good
8	Good	—
9	Good	—
10	Good	—

Table 4. Patient outcome related to intracranial pressure and cerebral perfusion pressure

Patient outcome	Total hours in ICU	Highest ICP (mmHg)	Lowest CPP (mmHg)
1 Transferred day 4	146.5	35	61
2 Died day 5	169.5	20	79
3 Died day 3	87	12	61
4 Transferred day 2	64	10	69
5 Died day 2	49	5	88
6 Transferred day 8	206	10	80
7 Transferred day 6	158.5	7	76
8 Transferred day 7	184	21	80
9 Died day 3	75	44	56
10 Transferred day 5	160	11	58
Mean	130		
SD	55.8		

Discussion

This study has shown that it is possible to use an infusion of propofol to sedate patients with head injuries in intensive care without causing significant decreases in cerebral perfusion pressure. The infusion rate was adjusted according to clinical requirements and the mean rate of infusion of propofol was 2.88 mg/kg/hour. Mean rates of infusion to provide maintenance of anaesthesia which have been reported range from 6.2 to 15.6 mg/kg/hour.¹⁴ The mean rate of infusion used to provide sedation for nonparalysed patients in intensive care was 1.93 mg/kg/hour¹¹ and after cardiac surgery the mean rate required to provide adequate sedation was only 0.78 mg/kg/hour;¹² however these latter patients had received high dose fentanyl anaesthesia before the study.

Bodyweight was estimated in all cases and this may have introduced errors when expressing the infusion rates per kilogram. However this reflects the clinical situation, when it is often impossible to weigh severely injured patients accurately. It is hoped that in future studies, facilities will be available to weigh patients in bed.

Arterial blood pressure and heart rate showed only minor increases and decreases throughout the study and no significant hypotension occurred. It should be noted, however, that no patient was hypovolaemic on admission to the study and the mean age of the patients in the study was 36.8 years.

Minor changes in ICP and CPP also occurred but there were no statistically significant increases in mean ICP. There was a significant decrease in ICP of 2.1 mmHg at 2 hours ($p = 0.049$). It has recently been shown that propofol reduces cerebral metabolic rate for oxygen,¹⁵ cerebral

blood flow¹⁵ and ICP,^{16,17} although large decreases in ICP were not expected since measures such as hyperventilation were already instigated before the start of the study. Mean CPP generally increased slightly during the study period and at 24 hours the increase of 9.8 mmHg was statistically significant. Generally both parameters remained within the limits of safety, ICP below 20 mmHg and CPP above 60 mmHg.

Patient 6 had a low MAP at the start of the study, with a compromised CPP. It was interesting to note that MAP increased in this patient and adequate CPP was restored after 8 hours of sedation. In patient 9, cerebral perfusion pressure decreased below 60 mmHg. This was associated with high levels of ICP and pupillary dilatation and responded to an infusion of mannitol. The patient later died as a result of his severe head injury.

Patient 1 had a high initial ICP despite hyperventilation and sedation, and after 8 hours of sedation with propofol infusion, ICP decreased to an acceptable level and remained below 20 mmHg for the remainder of the study period, except for a single reading of 39 mmHg at 20 hours. Cerebral perfusion pressure was satisfactory throughout the study period.

As experience was gained with the infusion technique, so clinicians were more willing to increase the rate of propofol infusion to increase sedation rather than resort to other sedative agents. It will be noted that patients 7–10 received a higher initial infusion rate.

The assessments of quality of sedation and recovery in this study are of necessity coarse. The use of sedation scores is not possible when patients are paralysed and so the parameters used to grade sedation were similar to those used to determine ‘lightness’ in patients during anaesthesia. Recovery of patients following severe head injury will obviously be determined by the severity of the injury as much as by the sedative used, therefore recovery was graded as an overall clinical impression rather than by any formal testing.

The cessation of ventilation was not taken into consideration in this study because often patients continued to require sedation and ventilation after the propofol infusion was stopped at 24 hours. Other groups of patients, for example after cardiac surgery, present more uniform therapeutic models in which extubation routinely follows withdrawal of sedation. The high mortality of this group reflects the severity of the initial head injury and compares both with previous experience in this unit and with recently published data.¹⁸

In conclusion, propofol is shown to be a suitable sedative agent in patients with head injuries requiring ventilation and ICP monitoring in intensive care.

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CASE REPORT

Tracheal dilatation followed by stenosis in Mounier-Kuhn syndrome

A case report

F. M. MESSAHEL

Summary

A patient with previously undiagnosed Mounier-Kuhn syndrome (tracheobronchomegaly) was admitted with a head injury after a fall. The trachea was intubated with an oral tracheal tube with high-volume low-pressure cuff. The intracuff pressure was within the normal safe range recommended by the manufacturer. However, the patient developed tracheal dilatation on the second day after intubation. The trachea was extubated on the 15th day, and it was noticed 48 hours later that the patient was developing a tracheal stenosis at the site of the previous dilatation. The stenosis was so severe that the patient underwent resection-anastomosis surgery of his stenotic tracheal segment 2 months after extubation. It may be preferable in patients with Mounier-Kuhn syndrome who require mechanical ventilation to intubate the trachea with an uncuffed tube and to pack the throat to decrease the chances of gas leak and inhalation.

Key words

Intubation; tracheal.
Complications; tracheal dilatation, tracheal stenosis.

The most serious long-term complications of the sealing function of the cuff of the tracheal tube, namely tracheal stenosis and/or tracheomalacia,¹⁻³ are due to ischaemic necrosis. Cases of tracheal dilatation have also been reported as a consequence of tracheal intubation.⁴⁻⁷ This is a report of a patient with Mounier-Kuhn syndrome in whom tracheal dilatation was noticed after 24 hours of intubation and was followed by tracheal stenosis which started soon after extubation.

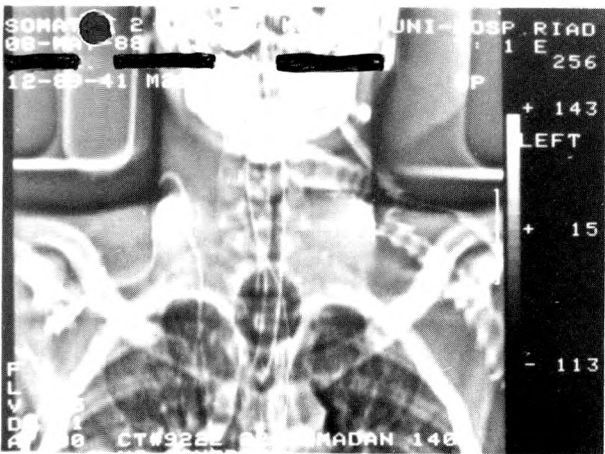


Fig. 1. A tomogram showing dilatation of the trachea at the cuff site.

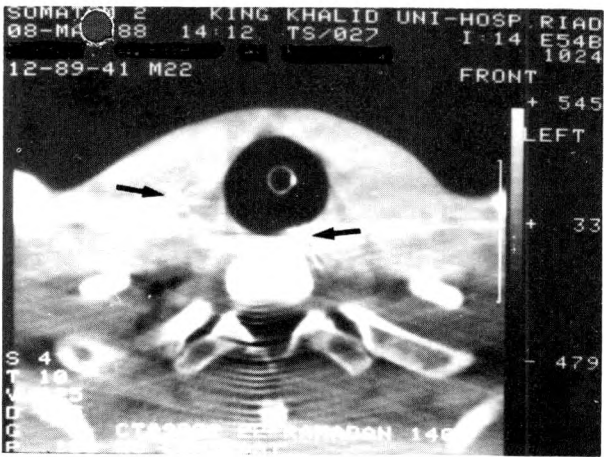


Fig. 2. CAT scan of the neck demonstrating marked tracheal dilatation at the cuff site. Tracheal tube in the centre. Arrows indicate nasogastric tube in oesophagus and central venous catheter.

Case history

A 22-year-old male was admitted to the surgical intensive care unit with a head injury as a result of a fall. He was unconscious and his trachea was intubated in the casualty department with an 8.5 mm internal diameter orotracheal

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Fig. 3. A sagittal CAT scan reconstruction of sections in the neck. Arrow points to tracheal dilatation with tracheal tube in middle.



Fig. 4. CAT scan of the neck showing tracheal stenosis 12 days after extubation.

tube with a high-volume low-pressure cuff (Mallinckrodt). A computerised axial tomographic (CAT) scan of the brain revealed the presence of cerebral oedema. Full mechanical ventilation was instituted and dexamethasone and mannitol were administered.

On the second day after intubation, a globular air shadow corresponding to the cuff of the tracheal tube appeared on the chest X ray (CXR). The intracuff pressure was checked immediately and was found to be 2.3 kPa (16.9 mmHg). The cuff was deflated after thorough pharyngeal toilet and a repeat CXR was taken. The globular air shadow did not disappear. Review of the pre-intubation CXR taken on arrival at the hospital revealed that the air column of the trachea and bronchi was wider than normal; when measured 2 cm above the projected top of the aortic arch it was found to be 29 mm (normal mean 17.5). A CAT scan of the neck showed marked dilatation of the trachea at the cuff site (Figs 1–3). The ratio of the inflated cuff diameter to the tracheal lumen diameter (C/T ratio) was found to be 2:1.

Six days later, there was evidence on the CXR of right lower lobe collapse as a result of mucus retention, and fiberoptic bronchoscopy was performed. The diameter of the tip of the bronchoscope is 6 mm and it was noticed that it



Fig. 5. Tomogram of the neck and upper chest revealing the stenosed tracheal segment at the previous site of dilatation.

reached the distal bronchioles easily and suction of retained mucus was completed faster and more efficiently than normal. At the end of this procedure the dilated part of the trachea at the cuff site was examined through the bronchoscope after deflation and outward withdrawal of the cuff. The trachea at this segment was found to be red and oedematous with multiple small necrotic spots. Fresh bleeding had started and the cuff was re-inflated to secure haemostasis. It was noticed also that the mucous membrane of the trachea below this dilated segment was redundant at two sites.

The patient's general condition improved and his trachea was extubated on the 15th day; the immediate postextubation period was uneventful. However, the dilated part of the trachea was no longer seen on the CXR after 24 hours. Narrowing of the tracheal air column was clear after a further 24 hours, and during the succeeding days it was evident that tracheal stenosis was inevitable since the narrowing of the tracheal lumen was progressive (Figs 4 and 5). Attempts to halt the stenotic process by bougie dilatation were unsuccessful and 2 months later the patient underwent resection–anastomosis of the stenotic segment of his trachea.

Discussion

Mounier–Kuhn syndrome (synonym: tracheobronchomegaly) was described first in 1932.⁸ It is predominant in males and the onset is in the third to the fourth decade of life, although Hunter *et al.*⁹ reported its occurrence in an 18-month-old child. The symptoms are indistinguishable from those of chronic bronchitis and emphysema. It is of unknown aetiology but a familial tendency with possible autosomal recessive inheritance has been described.¹⁰ Congenital malformation of the trachea may lead to increased compliance of the trachea and bronchial walls. The cartilaginous and membranous parts of the trachea and bronchi show thin, atrophied muscular and elastic tissue. This may lead to tracheobronchial collapse with signs of chronic infection. The latter can result in respiratory insufficiency and cor pulmonale. Radiological diagnosis is made when the transverse diameter of the trachea, measured 2 cm from the projection of the aortic arch, exceeds 30 mm.¹¹ On bronchoscopy, the picture may simulate multiple diverticula. An association between this syndrome and Ehlers–Danlos syndrome has been reported.¹²

In this case, the diagnosis of Mounier-Kuhn syndrome was based on the radiological findings, the wide calibre of the bronchioles, the presence of tracheal protrusions on bronchoscopy and the speed at which tracheal dilatation and stenosis occurred. The transverse diameter of the trachea of this patient on the pre-intubation CXR was 29 mm, very close to the arbitrary figure of 30 mm adopted by Fraser and Paré;¹¹ this patient was at the lower end of the age range at which the syndrome becomes evident. The ease with which the distal end of the fiberoptic bronchoscope was accommodated in the distal bronchioles demonstrated the wide calibre of the whole of the tracheobronchial tree, although Gay and Dee¹³ noticed abrupt transition to normal calibre of the terminal airways on the bronchograms of two patients with Mounier-Kuhn syndrome.

The thin, atrophied, muscular and elastic tissue of both cartilaginous and membranous portions of the trachea and bronchi result in abnormal flaccidity and easy collapsibility of their walls. This causes protrusion of redundant musculomembranous tissues between cartilaginous rings (known sometimes as tracheal diverticulosis). There were two such diverticula in this patient's trachea below the dilated segment.

Attention was drawn to the tracheal abnormality by the development of dilatation at the cuff site only 24 hours after intubation and in the presence of a normal intracuff pressure. Khan and Reddy¹⁴ found that marked tracheal damage occurs in patients with C/T ratio above 1.5:1. The C/T ratio was 2:1 in this patient.

Three possible courses of action were considered in the attempt to halt the progress of the lesion. The replacement of the tracheal tube by an uncuffed one would have increased the risk of inhalation, and there was no guarantee that the process of stenosis had not started already. Intermittent inflation of the cuff would have been associated with risks of inhalation, formation of tracheo-oesophageal fistula,¹⁵ or erosion into a major blood vessel.¹⁶ Tracheostomy might have caused the same complications but at a lower tracheal segment.

Tracheal stenosis occurred in this patient with an unexplained speed. It was predicted that the resulting stenosis would be a severe one. Fibrous tissue formation occurs in and around the tracheal wall in tracheal stenosis and it is a normal finding during tracheal reconstructive surgery that dense adhesions are encountered between the tracheal stenosis and the surrounding tissues.¹⁷

It was impossible to prevent tracheal dilatation in this

patient. However, in cases of Mounier-Kuhn syndrome it may be preferable to intubate the trachea with an uncuffed tube together with proper throat packing to minimise or prevent gas leak and risk of inhalation. Tracheal damage is very unlikely provided that the tip of the uncuffed tracheal tube does not touch the inside wall of the trachea.

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CASE REPORT

Laryngeal anaesthesia with aspiration following intubation

W. AUCOTT, P. PRINSLEY AND G. MADDEN

Summary

Two patients who had undergone emergency tracheal intubation developed signs of aspiration of ingested food. Nasendoscopy demonstrated supraglottic anaesthesia which recovered from the laryngeal margins in towards the vocal cords. It is assumed that this was caused by a neuropraxia of the internal branch of the superior laryngeal nerve, presumably as a result of trauma related to intubation.

Key words

Intubation; tracheal.

Complications; aspiration.

Case histories

Case 1

A 72-year-old man was admitted with myocardial infarction. He suffered a cardiac arrest and subsequently developed aspiration pneumonia for which he required prolonged ventilatory support. An orotracheal tube was in place for 2 weeks. This was pulled out on five occasions. Reintubation was described as 'difficult'. Tracheostomy was then performed. Ventilatory support was required for a further period of 2 weeks. Subsequently, the patient could cough and had a normal voice. However, when solid food was introduced it was expectorated immediately through the tracheostomy.

Laryngoscopy with a flexible nasendoscope showed normal laryngeal mobility but a loss of sensation. There was no cough reflex when the epiglottis, ventricular bands or vocal cords were touched. The endoscope could be passed easily into the subglottic region.

Progressive return of laryngeal sensation was demonstrated by repeated nasendoscopy. A cough reflex was elicited by touching the false cords one week later and by touching the true cords after a further week. A contrast X ray study at this time showed no aspiration, and oral feeding was reintroduced without difficulty.

Case 2

A 61-year-old man suffered a myocardial infarction and

respiratory failure 9 days after cholecystectomy. His trachea was intubated and he was transferred to the Intensive Care Unit. Continued ventilation was required for chest infection and so tracheostomy was performed after 9 days. He was well enough to be given sips of water 4 weeks after the initial episode, but the water reappeared immediately through the tracheostomy.

No cough reflex was elicited at nasendoscopy. However, it returned progressively from the epiglottis and aryepiglottic fold across to the vocal cords by the seventh week after intubation.

Discussion

A recent study of 'dysphagia in acute stroke'¹ concentrated on motor dysfunction. Sensory problems are given little attention in most accounts of aspiration except after supraglottic laryngectomy.

Aspiration was obvious immediately in these two patients because of the tracheostomy. The possibility may not be suspected in patients with no tracheostomy if a good cough is present. The supraglottis is innervated by the internal branch of the superior laryngeal nerve. This pierces the thyroid membrane and passes down inside the thyroid cartilage.² Local anaesthetic block of the nerve via the thyroid membrane has been used to facilitate intubation or laryngeal instrumentation.³

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Tracheal intubation has been associated with vocal cord palsy.⁴ It has been suggested that the anterior branch of the recurrent laryngeal nerve may be compressed against the thyroid lamina by a high cuff. It is interesting that both patients reported here recovered over about 6 weeks. We suggest that the internal branches of the superior laryngeal nerves were traumatised by instrumentation during difficult intubation or by the cuff in the process of agitated self-extubation.

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CASE REPORT

Stridor in an adult



An unusual presentation of functional origin

N. S. MORTON AND G. W. BARR

Summary

A 34-year-old woman with a recent history of a influenza-like illness and signs of bronchopneumonia presented with many of the features of acute epiglottitis, a condition which still carries a high mortality in adults. Urgent laryngoscopy and bronchoscopy under inhalational anaesthesia were negative. The results of arterial blood gases, taken when stridor was at its worst, revealed marked hypocapnia and respiratory alkalosis. We conclude that the resultant acute reduction of serum ionised calcium produced stridor as a result of tetany of the vocal cords. Similar cases from the literature and the role of emotional factors in the aetiology are discussed.

Key words

Airway; obstruction.

Acid-base equilibrium; respiratory alkalosis.

Acute epiglottitis is relatively rare in adults (9.7 cases per million adults per year) but the incidence appears to be on the increase.^{1–4} The mortality rate of approximately 7% (range 0 to 90%) is significantly higher than the current rate of less than 1% among children.^{1–5} The progression of supraglottic inflammation and swelling tends to be slower in adults and does not always involve the epiglottis, but fatal airway obstruction can occur at any time without warning.^{4–6} It is urgent that prophylactic protection of the airway is established in adults, as is the practice in children.^{1–7}

Case history

A 34-year-old woman with rapidly worsening inspiratory stridor was referred as an emergency from the Infectious Diseases Unit. She was very agitated, tachypnoeic, tachycardic and pyrexial (37.8°C) with marked inspiratory stridor and suprasternal indrawing. She was sitting upright and coughing intermittently to clear saliva which she was unable to swallow. Her voice was hoarse and she had marked facial flushing, moderate peri-orbital oedema but no frank angioneurotic oedema. Her throat looked mildly inflamed but was not grossly swollen or oedematous. She was not cyanosed when breathing 24% oxygen; chest movements were symmetrical and of good volume; the percussion note was dull at both lung bases. Vesicular breath sounds and occasional crepitations were heard on auscultation. No arterial blood gas results were available

at this time although a sample had been sent urgently to the laboratory in another hospital.

The recent medical history was of general malaise for one week, followed by a sore throat and dry cough for 3 days and anorexia, myalgia and feverishness for one day. Dyspnoea and stridor developed on the afternoon of admission.

The presumptive diagnosis was acute epiglottitis; it was considered to be inappropriate to undertake urgent neck radiology and escorted transfer was therefore arranged to the ENT theatre. An inhalational induction of anaesthesia with halothane in oxygen was started with the patient in the semi-sitting position. It was notable that during induction of anaesthesia, the patient's stridor improved very quickly and manual ventilation of the lungs by bag and facemask could be carried out easily. Laryngoscopy, pharyngoscopy, upper oesophagoscopy and bronchoscopy were all normal. The epiglottis and supraglottic tissues in particular showed no signs of inflammation; there was no foreign body and vocal cord movements were normal. The airway was secured with a tracheal tube and a short course of steroids was begun to prevent mucosal oedema due to instrumentation of the airway. Antibiotic therapy was also started.

The results of arterial blood gas analysis in the blood taken when stridor was at its worst now became available and revealed a marked respiratory alkalosis (pH 7.68, PaCO₂ 1.89 kPa, PaO₂ 17.33 kPa base excess + 2 mmol/litre, (Fio₂ 0.24).

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The patient's trachea was extubated 12 hours later with no recurrence of stridor. She continued to require oxygen therapy by facemask for a further 24 hours and had a productive cough for a further 3 days. It was noted during her stay in ICU that there were signs of stressed interpersonal relationships with her family and this may be a factor in the aetiology of the stridor (see below). She was discharged home one week after presentation. All sputum cultures were negative and serial titres for legionella, mycoplasma and viruses were negative.

Discussion

Our initial management of this patient was similar to the plan we follow for children with acute epiglottitis.⁷ We were very aware of the high mortality of adult acute epiglottitis and its unpredictable rate of progression to complete airway obstruction.¹⁻⁶ Inter-hospital transfer was required to ensure a safe environment for induction of general inhalational anaesthesia in the ENT operating theatre where experienced anaesthetic and ENT help were available.

The negative endoscopy excluded epiglottitis, foreign body aspiration and disorders of vocal cord mobility. We did not have available a serum ionised calcium analysis, but hypocapnia and respiratory alkalosis were confirmed by arterial blood gas and pH results. Alkalosis produces a reduction in the amount of ionised calcium in the serum because it increases the tendency for calcium to become bound to plasma proteins. A reduction in the ionised calcium fraction increases the permeability of cell membranes to sodium and potassium, which in turn increases the excitability of muscle and nervous tissue.⁸ For the laryngeal musculature, this results in laryngeal spasm which produces inspiratory stridor. Moore⁹ showed that serum ionised calcium changes by 0.04 mmol/litre per 0.1 unit change in pH. This would result, in our patient, in a decrease in serum ionised calcium of 0.112 mmol/litre assuming a pH increase of 0.28 units (i.e. 7.40–7.68). A rapid change of this magnitude could be associated with the well recognised symptoms and signs of hypocalcaemia¹⁰ namely tetany, muscle cramps, Trousseau's sign, Chvostek's sign, stridor and even convulsions.

An acute reduction of serum ionised calcium can occur after parathyroidectomy, or after thyroidectomy where the parathyroid glands have been inadvertently removed or damaged.⁸

Stridor may be the presenting feature of hypoparathyroidism in a child and in the neonatal period; premature babies and infants of diabetic mothers are particularly at risk. Infants with birth asphyxia are also prone to hypocalcaemia, but in this case the mechanism is overproduction of calcitonin.¹¹ Watchko *et al.*¹² found that in neonates, the change in serum ionised calcium per unit change in pH was twice that of adults. Stridor has recently been described in a patient with metabolic alkalosis due to hypokalaemia induced by diuretic therapy.¹³

Our patient showed some evidence of family stress which may have contributed to an anxiety or hysterical hyperventilation state. Similar cases have been described in the psychiatric literature as part of the hyperventilation syndrome,¹⁴ in adults¹⁵⁻²⁰ and in children.²¹ Some patients had had multiple hospital admissions and some

had undergone tracheal intubation or tracheostomy.¹⁸ Alkalosis was excluded in some cases as a precipitating cause of stridor and some patients participated in inspiratory and expiratory flow studies which indicated an ability to voluntarily produce inspiratory stridor.¹⁷ These patients had on testing a marked reduction in peak inspiratory flow rate but normal airways' resistance, the characteristic features of upper airways obstruction.

Many psychiatrists suggest that functional or nonorganic airway obstruction represents an important consideration in the adult with airway obstruction. However, the hyperventilation syndrome has many causes which may co-exist.^{22,23} The combination of the sensation of dyspnoea associated with a developing bronchopneumonia,²³ an anxiety or hysterical state and hypocapnia with hypocalcaemia led our patient into a vicious cycle, particularly when the distressing symptom of stridor developed. Given the same clinical picture, we would find it difficult not to follow the same or a similar management plan. The reports of functional airway obstruction all stress the importance of examination of the larynx to exclude organic pathology. It still remains controversial whether this should be done by indirect or direct laryngoscopy and whether the patient should be awake or anaesthetised when the examination is made. The role of neck radiology is also controversial because there is an incidence of false positive and false negative results.

We still hold with the general United Kingdom view, supported recently in Canada,¹ that examination of the larynx and prophylactic tracheal intubation after inhalational induction of anaesthesia with halothane in oxygen, in any patient with possible acute epiglottitis, is the safest way to proceed. We also consider that this should only be undertaken by an experienced anaesthetist in an environment with skilled anaesthetic and ENT help immediately available, in case a tracheostomy is required.

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CASE REPORT

Obstructive sleep apnoea

N. M. TIERNEY, B. J. POLLARD AND B. R. H. DORAN

Summary

A patient with obstructive sleep apnoea is described, who required admission to an intensive care unit on two separate occasions within 2 months. The first admission was after anaesthesia for operation on the upper airway. The second occurred after a relative overdose of an opioid analgesic was administered. The diagnosis, treatment and anaesthetic management of patients with this syndrome are discussed.

Key words

Ventilation; sleep apnoea.

Airway; obstruction.

Obstructive sleep apnoea results from a malfunction of the upper airway and results, in some patients, in severe hypoxaemia during sleep. This phenomenon may have acute and chronic sequelae. Current management of the syndrome is still being developed. Anaesthetists must be aware of the inherent problems of treatment and ways in which the various methods of treatment may influence patient management in the peri-operative period.

Case history

A 54-year-old man presented for surgery to relieve upper airways obstruction. He had a long history of loud snoring and daytime somnolence, and a diagnosis of obstructive sleep apnoea had been made. The diagnosis had been confirmed by nocturnal oxygen saturation monitoring. In addition, the patient suffered from chronic obstructive pulmonary disease and peripheral vascular disease.

His lung disease was controlled with inhaled salbutamol 200 µg four times daily and oral frusemide 60 mg, twice daily. He was also taking protriptyline 20 mg twice daily in an effort to reduce the episodes of nocturnal hypoxaemia, and chloroquine 20 mg twice daily for peripheral vascular disease.

Laboratory investigations revealed a haemoglobin concentration of 17.5 g/dlitre and urea and electrolyte concentrations were within the normal range. A random arterial blood gas sample taken while breathing room air, showed pH 7.34; P_{aO_2} 7 kPa; P_{aCO_2} 6 kPa. The forced expiratory volume in one second was 1 litre (30% of predicted) and the forced vital capacity 2.24 litres (52% of predicted). The electrocardiogram indicated right axis deviation and bi-

atrial enlargement, together with global ischaemic changes. The chest radiograph demonstrated gross cardiomegaly but was otherwise normal.

The patient was premedicated with temazepam 10 mg orally, one hour before operation. After pre-oxygenation, anaesthesia was induced with propofol 100 mg, and suxamethonium 100 mg was administered. The trachea was intubated without difficulty and anaesthesia was maintained with nitrous oxide, oxygen, halothane 0.5% and atracurium. The inferior nasal turbinates were trimmed and the nose was packed. The surgeon reported that the supraglottis was 'floppy and liable to involute'.

Neostigmine 2.5 mg and atropine 1.0 mg were administered at the end of surgery. The train-of-four ratio was measured as one 5 minutes later. Spontaneous breathing returned and the patient was moved into a sitting position in an effort to improve his respiratory function. The trachea was extubated. His conscious level deteriorated within 10 minutes and he became cyanosed despite administration of 100% oxygen by facemask and relief of obstruction by forward displacement of the mandible. His trachea was reintubated immediately, controlled ventilation was begun, and he was transferred to the intensive care unit.

We thought that opioids should be avoided; consequently, propofol was infused as a sedative. A cannula was inserted into his right internal jugular vein; his central venous pressure was 18 cm H_2O . An infusion of dobutamine was started; the right heart failure rapidly improved and there were increases in arterial pressure and peripheral perfusion. An electrocardiogram was performed which revealed no changes from previous recordings.

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It was possible to wean the patient from controlled to spontaneous ventilation 12 hours later. Continuous positive airways pressure (CPAP) of 0.5 kPa was required to maintain acceptable blood gases. The tracheal tube was tolerated well and was left in place to maintain his airway. P_{aO_2} was more than 9.3 kPa with an F_{iO_2} of 0.5. Three prolonged apnoeic episodes were observed while the patient slept, which suggested a degree of centrally induced apnoea.

The nasal packs were removed 4 days later and his trachea was extubated. He maintained acceptable blood gases and was returned to the ENT ward. He was discharged from hospital 3 days later. The patient was seen in the outpatient clinic 6 weeks after discharge and was noted to be much improved. The episodes of daytime somnolence had resolved. A small but persistent ischaemic ulcer remained over the site of the previous indwelling arterial line.

He was admitted to another hospital 2 weeks later with worsening ischaemic changes in his legs. He complained of severe pain in both feet and was given phenazocine 5 mg orally on two occasions within 3 hours. He suffered a respiratory arrest shortly afterwards. He was resuscitated and transferred to the hospital's intensive care unit, where he required mechanical ventilation for 21 days. A tracheostomy was performed during this period and he was weaned slowly from ventilatory support. He spent a total of 30 days on the intensive care unit. The ischaemic changes in his legs remain at the time of writing, and prevent his discharge from hospital.

Discussion

The patient described has one form of the sleep apnoea syndrome. He suffers also from chronic obstructive pulmonary disease, an uncommon but previously reported combination.¹ Sleep apnoea is defined as a 10-second pause in ventilation during sleep; sleep apnoea syndrome is diagnosed if more than 30 apnoeic episodes occur during 7 hours of nocturnal sleep.² This definition has been challenged because the frequency of apnoea increases normally with age,³ but in practice it remains the most applicable. Usually, the sufferer has so many apnoeic episodes (some individuals are apnoeic for half the time that they are asleep) that the diagnosis is not difficult if sleep studies are made.⁴ The first accurate description of a patient with sleep apnoea syndrome was made by Broadbent⁵ in 1877. The term 'Pickwickian' was coined subsequently by Burwell⁶ in 1956 to describe an obese individual with hypersomnolence and right heart failure, but the connexion was not made at that time between these symptoms and ventilatory changes which occurred during sleep.

Techniques are available now which allow recognition and recording of apnoeic episodes during sleep.⁷ The most valuable is a continuous record of oxygen saturation.⁸ More sophisticated analysis requires monitoring of ventilatory mechanics (airflow and thoracic cage movement) to differentiate between central and obstructive episodes.

Normal individuals have pauses in ventilation during sleep and one quarter of the adult population is thought to snore.⁹ Severe sleep apnoea was estimated to occur in 0.5–3% of a working male population in a questionnaire survey from Israel;¹⁰ the incidence was higher in males although this inequality is less after the female menopause.¹¹

Snoring is the cardinal symptom of obstructive sleep

apnoea. Often, the description is given by the spouse who is kept awake by the noise. The sound is generated by air drawn through a narrowed hypopharynx which becomes narrower as the patient develops lower and lower intrathoracic pressures.¹² Increasing collapse of the upper airway results, and prevents effective ventilation. Hypersomnolence is a common complaint also; the patient falls asleep at entirely inappropriate moments. It has been suggested that hypoxaemia rather than intermittent arousal is the cause for this symptom.¹³

A number of conditions are associated with the sleep apnoea syndrome. Both systemic and pulmonary hypertension occur during apnoeic episodes.¹⁴ Chronic disease may result in permanent rather than transient pulmonary hypertension.¹⁵ Systemic hypertension is often a co-existent finding in these patients although a causative relationship has not been proven. Hypoxaemia may also cause secondary polycythaemia. Benign cardiac arrhythmias are common in normal patients during sleep.¹⁶ Their incidence increases in individuals with obstructive sleep apnoea¹⁷ although the presence of more serious arrhythmias, e.g. ventricular tachycardia, seems to be similar (1–3%) in 'normal' individuals and those diagnosed as having obstructive sleep apnoea.¹⁸

The treatment of this syndrome is not simple, as evidenced by the wide range of techniques employed. Obesity is a common, but not an essential finding, in obstructive sleep apnoea. Weight loss may reduce the incidence of hypoxaemic episodes in some patients.¹⁹ Relief of upper airway obstruction should be attempted with appropriate surgery, which may include conventional ENT procedures (nasal obstruction is common), or methods developed to alter the anatomy of the airway. Tracheostomy is probably the surgical treatment of choice²⁰ but is not without problems, especially in patients with sleep apnoea syndrome and pulmonary disease, where the episodes of obstructive hypoxaemia are relieved by tracheostomy but are replaced by more prolonged desaturation during rapid eye movement (REM) sleep.²¹ Other surgical techniques such as uvulopalatopharyngoplasty, evolved originally to treat snoring, have been applied with beneficial effects, although there is doubt about their long-term efficacy.²²

The administration of oxygen alone has an unpredictable effect on these individuals²³ but its application through a nasal mask with added CPAP seems to be effective despite the cumbersome equipment.²⁴ The effectiveness of drug therapy is rather disappointing; many agents have been tried, e.g. protryptiline,²⁵ medroxyprogesterone²⁶ and almitrine.²⁷

Clearly, patients with obstructive sleep apnoea may present problems to the anaesthetist in the peri-operative period and previous case reports have documented such events.^{28,29} Pre-operative treatment of chest and lung disease and of polycythaemia is necessary to optimise the patient's condition. Most authors would avoid the administration of a premedicant because of its potential for precipitating airway obstruction and apnoea,^{28,29} although temazepam was given in the case described without problem. Tracheal intubation is usually straightforward unless sleep apnoea is associated with diseases known to render intubation difficult, e.g. acromegaly,³⁰ Down's syndrome.³¹

The time of highest risk is the postoperative period. The risk of airway obstruction is high unless a tracheostomy is performed. The superimposition of residual effects of

anaesthetic drugs on a precarious airway makes immediate extubation of the patient a risky procedure. An attempt was made in the case reported here to use anaesthetic agents with 'clean' recovery characteristics, but immediate return of spontaneous ventilation was not possible. A recent study of respiratory function in narcotised postoperative patients has shown multiple obstructive apnoeas to be a significant cause of postoperative hypoxaemia.³² Careful postoperative observation of the patient is of paramount importance. Apnoea monitoring or pulse oximetry³³ may be useful adjuncts in the performance of this task. Consideration ought to be given to the use of local anaesthetic nerve blocks, if appropriate, during operation and to provide analgesia in the postoperative period.

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The laryngeal mask airway

A study of 100 patients during spontaneous breathing

P. M. BRODRICK, N. R. WEBSTER AND J. F. NUNN

Summary

A prototype size 3 laryngeal mask was used in 100 patients by 18 anaesthetists with no previous experience of its use. A clear and unobstructed airway was obtained in 98% of patients, without requiring support of the jaw, thus leaving the anaesthetists' hands entirely free. The patency of the airway did not deteriorate during the course of the anaesthetic. In 10 patients there was obstruction of the airway at the first attempt to place it without the introducer and this obstruction appeared to be as a result of downfolding of the epiglottis. Subsequent attempts at passage were successful in all 10 patients. The seal between the mask and the larynx was adequate for artificial ventilation of the patients, but the mean leak pressure was 1.7 kPa.

Key words

Complications; airway.

Equipment; laryngeal mask.

The laryngeal mask airway (LMA) is a new design of oral airway.¹ In engineering terms there are two possible ways to achieve a gas-tight seal between two tubes. Firstly, one tube can be inserted into the other and a seal effected. Secondly, an end-to-end seal can be achieved, if the configurations of the ends are exactly matched. It is this second approach which is taken with the LMA.

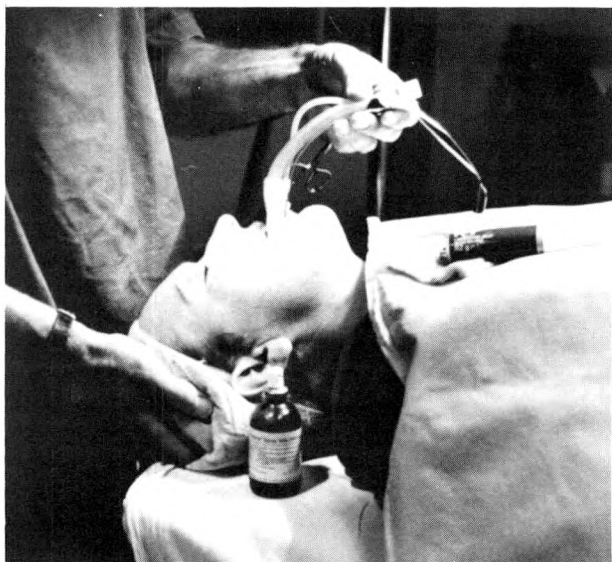


Fig. 1. The laryngeal mask airway prototype, seen with a mounted introducer.

A full description of a prototype LMA appears elsewhere.² It consists of a conventional silicone tracheal tube which has been cut diagonally across to remove the cuff (Fig. 1). An elliptical cuff is attached to the distal end which can be inflated through a pilot tube. The design derives from work done on cadaveric specimens of the male and female larynx and is such that the elliptical cuff forms an airtight seal around the posterior perimeter of the larynx.

It has been suggested that the LMA can be used in preference to tracheal tubes and will permit positive pressure ventilation with a gas-tight seal to 2.0 kPa. Its use during anaesthetics with spontaneous breathing is also advocated since it permits maintenance of a good airway while the anaesthetist is free to use both hands for other functions. The LMA is also reported to have been used successfully in three cases of difficult intubation.³ In addition, it is suggested that it may be a useful device for use by paramedical staff.

Two studies of the LMA were performed previously by its designer^{1,2} using a prototype LMA, but no independent trial has as yet been undertaken. We have therefore undertaken a clinical trial of the prototype to assess its suitability for routine use with spontaneously breathing patients.

Methods

Observations on the performance of a prototype LMA (size 3) were made on 100 consecutive patients on routine elec-

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Table 1. Demographic and operative details of the patients, (%). Values expressed as mean (SD).

Males/females	72/28
Age, years	62.56 (17.79)
Build: Small	18
Medium	54
Large	28
Potential airway problems	7
Operation: General surgery	5
Genito-urinary	74
Gynaecology	3
Orthopaedics	18

Table 2. Mean anaesthetic details (%).

Anaesthetist	Individuals	Cases	Mean number of insertions	Range
Consultant	6	30	5.0	1–17
Senior registrar	3	37	12.3	2–25
Registrar	3	15	5.0	1–9
Senior House Officer	6	18	2.6	2–4
Total	18	100	5.3	1–25

tive surgical lists (Table 1). The only exclusion criteria were nonavailability of an LMA, patients less than 21 years of age, requirement for tracheal intubation (including artificial ventilation) and any potential risk of gastric regurgitation. Some were admitted as day cases the rest stayed in overnight after surgery.

In total, 18 different anaesthetists, who varied in experience from SHOs to consultants, participated in the study; each inserted a mean of 5.3 airways, (range 1–25) (Table 2). None had previous experience in the use of the LMA.

Premedication was according to the preference of each anaesthetist, and comprised no premedication, an intramuscular opioid and drying agent or an oral benzodiazepine. Anaesthetic technique was also according to individual preference and consisted of an intravenous induction agent (usually thiopentone or propofol) and was usually followed by maintenance with a volatile anaesthetic in 70% nitrous oxide and 30% oxygen. Patients were allowed to breathe spontaneously from a Magill system with a fresh gas flow of at least 7 litres/minute.

The LMA was inserted as previously described.² However, to assess the suitability of the device for use by personnel without previous experience, no detailed instructions or demonstrations of insertion were given. Each anaesthetist was given general guidelines, that included the use of the introducer, lubricating jelly and the direction of insertion. They were told how to ascertain the correct final position by feeling resistance to further downward movement and the slight forward bulging of the larynx when the cuff was inflated. The end-point for cuff inflation was determined by the absence of any audible or palpable leak around the cuff. Airway patency was assessed on the basis of three criteria: the absence of extraneous airway sounds; the presence of a normal pattern of excursion of the reservoir bag; the absence of any out-of-phase respiratory movements of the chest and abdomen.

The device was withdrawn and anaesthesia maintained until a further attempt was made, if patency was not achieved easily on the first attempt. The introducer was used for the second attempt if it appeared that airway obstruction was caused by downfolding of the epiglottis. In those cases where there was inadequate anaesthesia, the an-

aesthetist increased the concentration of volatile anaesthetic in the inspired gas and made another attempt after 2–3 minutes. In no case was laryngoscopy used for insertion.

After use, the LMA was washed thoroughly in soap and water, then soaked in a 0.5% solution of chlorhexidine in 70% alcohol and finally rinsed in water. However, the recommended technique of sterilisation is by autoclaving between each use, after washing and deflating the cuff.

In addition, the patients' demographic data, potential airway problems, type of operation performed, grade of anaesthetist and anaesthetic technique used were recorded. We also noted the patency of the airway, relative ease of insertion, volume of air injected into the cuff, quality of the resulting airway, ability to ventilate the lungs through the LMA, difficulties with removal and postoperative complications. The timing of removal as well as the duration the LMA was in position were noted.

The leak pressure was determined at 5-minute intervals, in 39 patients, by manual compression of the reservoir bag with closed relief valve while listening for the escape of gas at the mouth. Airway pressure was measured with an anaeroid gauge which had been calibrated against a water manometer.

Patients were asked specifically if they had a sore throat and for any postoperative sequelae either the next day after their operation, or, in the case of day cases, immediately before discharge from hospital.

Results

Once the LMA was passed, a clinically satisfactory airway was eventually obtained in 98 patients without the need to support the jaw, extend the head or to handle the patient in any way (Table 3). The LMA could be passed at a depth of anaesthesia which provided moderate relaxation of the jaw and slightly deeper than that for the insertion of an oropharyngeal airway. It passed easily without the introducer in 92 patients and resistance to passage increased abruptly when the cuff reached the level of the larynx. The larynx was then seen to move slightly anteriorly when the cuff was inflated.

Insertion was successful at the first attempt on 80% of occasions with a clinically satisfactory airway and an uninterrupted breathing pattern (Table 3). Of the remaining 20 patients, a satisfactory airway was obtained in 70% at the second attempt. A third attempt was successful in four of the remainder and the LMA was replaced with a Guedel oropharyngeal airway in the other two. In 10 patients there was clinical evidence of severe airway obstruction that was deemed to be as a result of the downfolding of the epiglottis. In all these patients, the airway was cleared by removal and reinsertion, five with the aid of the introducer (Table 3). The device was found to have rotated during insertion to face posteriorly in two patients. Coughing or laryngospasm occurred in 10 patients in whom anaesthesia was inadequate, which required removal of the device and deepening of anaesthesia before reinsertion was attempted (Table 4).

The probability of success at the first attempt appeared to be no less than with subsequent attempts (Fig. 2) and trainees seemed to fare no worse than consultants. It was possible to achieve adequate manual ventilation by bag

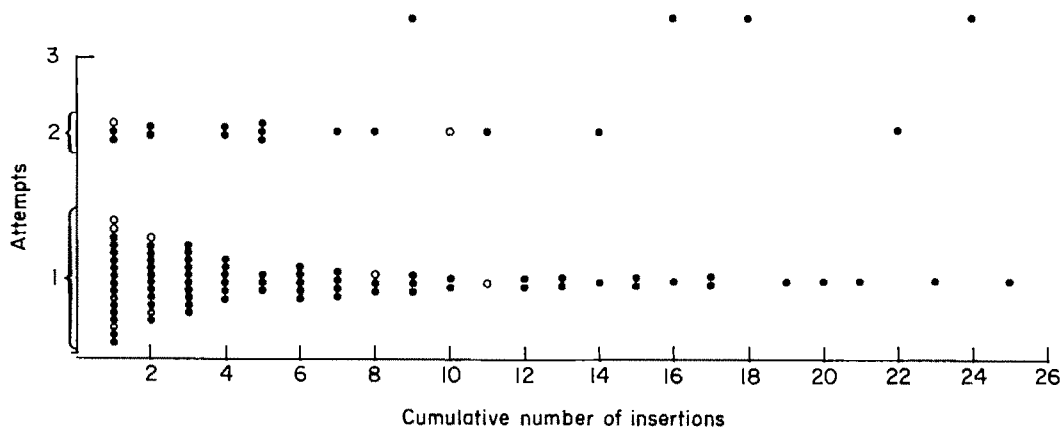


Fig. 2. The number of attempts by an individual anaesthetist to position the device successfully, related to overall accumulated experience. ●, no airway problem anticipated; ○, airway problem anticipated.

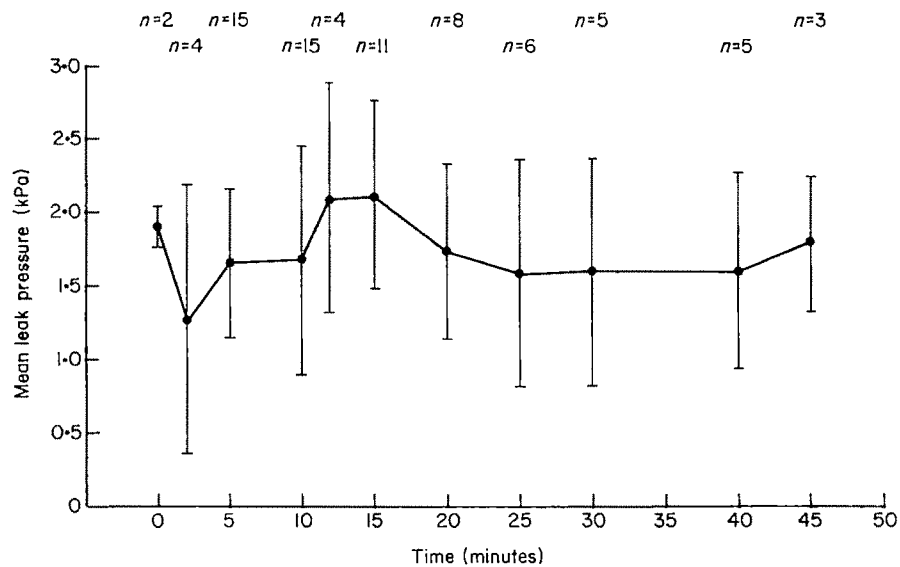


Fig. 3. The change in mean leak pressure around the LMA (*in situ*) during surgery. Mean (+/- SD).

Table 3. Details of insertion (*n* = 100).

Satisfactory airway	98
Attempts at insertion (use of introducer)	
1.	80 (1)
2.	14 (5)
3.	4 (2)
Abandoned	2 (0)
Mean	1.2
Inflation of cuff (ml)	18.8 (SD 3.5)
Ability to ventilate	90

Table 4. Complications with insertion of the airway (*n* = 27) (%).

Epiglottic obstruction	10
Coughing	6
Laryngospasm	4
Poor position	6
Excessive salivation	1

compression in 90 patients, albeit with an undefined leak. However, in eight patients the leak was so large as to make ventilation inefficient and potentially inadequate. The mean airway pressure at which leakage of gas occurred was 17 cm water and did not change with time (Fig. 3).

The LMA was removed in the operating theatre in 69 patients. In the remainder, the patient was transported to the recovery room with the device *in situ*. Six patients coughed and four clenched their teeth during removal of the airway in the recovery room. Firm traction was required in order to remove the airway in the latter cases. Two patients had temporary stridor on removal which quickly settled. The airway remained in place for a mean time of 32.4 minutes (range 7–105). Twelve patients had a temporary sore throat in the postoperative period.

Discussion

There were three outstanding advantages of the LMA in patients who breathed spontaneously. Firstly, excellent airway patency was obtained in 98% of patients and did

not deteriorate during the course of the anaesthetic. This is in contrast to problems associated with the prolonged effort which might be required by the anaesthetist when holding the jaw forward with an oropharyngeal airway in place. The LMA thus appears suitable for a lengthy anaesthetic with spontaneous breathing, when tracheal intubation might otherwise be considered. Secondly, as no manual support of the jaw was necessary the hands of the anaesthetist were freed for monitoring, record keeping and other tasks. Thirdly, it was possible to maintain a clear airway throughout transfer of the patient to the recovery room.

It is very easy to pass the LMA to the level of the larynx, but it is essential to verify that the airway is patent. There was obstruction of the airway in 10% of patients, almost certainly as a result of downfolding of the epiglottis. Manipulation of the jaw or positioning of the head did not improve the airway in any of these patients and it is essential to recognise this complication and remove the airway at once. We recommend the use of the introducer at the second attempt of insertion because of the possibility of downfolding of the epiglottis. The introducer is designed to facilitate insertion of the device and guarantee correct positioning of the epiglottis, by elevating it on withdrawal of the introducer.² Its use was successful in all of the five patients in whom it was used when the airway was inserted for the second or third time (Table 3). Many of our patients were elderly men in whom the epiglottis tends to be large, floppy and posteriorly placed. It is probably wise to use an introducer in all such cases. It is also said that the incidence of downfolding of the epiglottis is reduced when the device is passed under propofol anaesthesia (Brain, personal communication). The second problem is backward rotation of the device which occurred during insertion in 2% of our patients. This could probably be prevented by having a prominent line along either the front or the back of the device. This is already featured in a subsequent prototype which is more resistant to rotation (Brain, personal communication).

Artificial ventilation was possible in 90%, but there was a leak above a mean airway pressure of 1.7 kPa, which is slightly lower than that reported by Brain.² Despite trying some of the manoeuvres suggested by the inventor, such as changing the airway position and increasing or decreasing the volume of air in the cuff,¹ there seemed no obvious way to overcome this problem. In no case was there any evidence of regurgitation. It should be stressed that only size 3 was available to us and in many of our patients a larger size might have been more appropriate had it been available.

There were no problems associated with insertion of the

LMA in those patients with potentially difficult airways as assessed by physical examination. A much larger series of patients with potentially difficult airways will be required to determine its usefulness for this category of patients. Our series did not include any patient who had a history of intubation difficulty. Three such cases have been previously published³ and we believe a study should now be mounted to assess its usefulness in such patients. The LMA might well be a valuable addition to the equipment kept specifically for 'difficult' intubation cases, but with the limitation described above relating to positive pressure ventilation.

Protection during transfer to the recovery room could be a useful feature and the ease of extubation and the lack of sequelae make it possible for the patients to be extubated by the recovery room staff. However, when patients are transferred with the airway *in situ*, it is essential to provide a bite block to prevent them clenching their teeth on the device.

The incidence of postoperative sore throat (12%) was of the same order as the 9% reported by Jensen and his colleagues⁵ for anaesthetised patients without tracheal intubation. It appears considerably better than in patients who had tracheal intubation (28%).^{2,6} Our incidence was, however, higher than in Brain's series² in which 3.9% of patients who had had the LMA inserted complained of a sore throat. His anaesthetists may have had more experience in the use of the LMA.

The use of the LMA by paramedical personnel would appear to be attractive because insertion is simple and no laryngoscope is required. However, it would be essential for them to be trained to recognise obstruction of the airway. This is analogous to recognition of a misplaced tracheal tube.

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Characteristics of the Pharmaseal continuous flushing device

M. S. MCKINNEY AND I. A. ORR

Summary

Pharmaseal continuous flushing devices were tested with regard to flow characteristics into simulated arterial and venous pressure systems. Two driving pressures were used and it was found that variation in driving pressure made a significant difference to the flow, while arterial or venous pressure made no significant difference. The flow devices had a wide variation although they were all of the same type. The fluid volume delivered was in the region of 100 ml in a 24-hour period.

Key words

Equipment; arterial cannulae, continuous flow devices.

Modern anaesthetic and intensive therapy techniques often use both direct arterial and venous pressure monitoring. Continued patency of the cannulae used for these purposes

is usually ensured by a continuous flow device which allows a continuous infusion of a heparin-containing solution. These methods are increasingly applied to the paediatric and neonatal fields and some concern has been expressed about fluid overload of these susceptible individuals,¹ especially as the actual flow has been occasionally at variance with the accompanying literature.² Frequently, when these devices are used for young children, the driving pressure of the infusion bag is reduced in the belief that this will reduce the volume of fluid infused.

Cardiac intensive care units often use a continuous flow device to ensure patency of catheters set up for continuous monitoring of central venous pressure, systemic arterial pressure and pulmonary arterial pressure. This obviously increases the fluid delivered to the patient via these devices by a factor of two or three. It would also seem reasonable that the lower pressures in the venous and pulmonary systems might lead to a greater volume being infused.

We therefore investigated the effects on the delivered volume *in vitro* using Pharmaseal flow devices, which are the ones commonly employed in this cardiac surgical unit. These instruments present a very narrow lumen for the passage of fluid, a fine hole through a solid perspex cylinder. A shaped pliable sleeve surrounds this cylinder to form a tight seal to the passage of fluid. When the sleeve is deformed by squeezing on the sides, a large lumen forms at the top, outside the central cylinder, to allow the 'flush' of which these devices are also capable (Fig. 1).

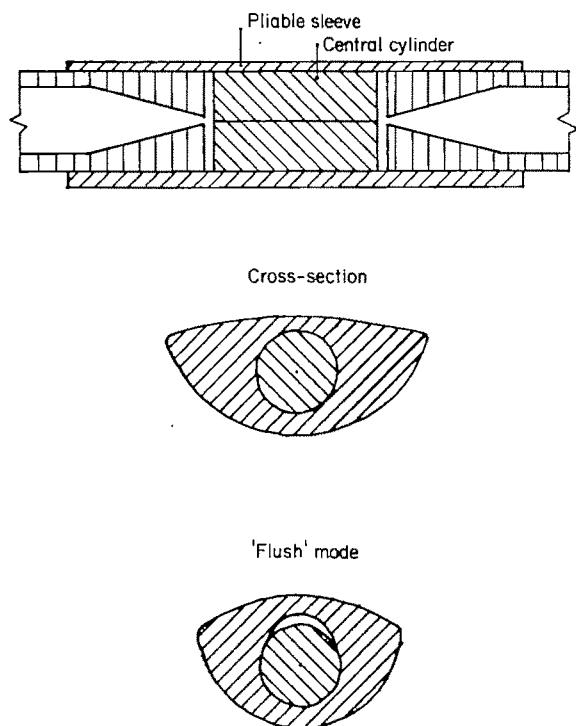


Fig. 1. Diagrams of the Pharmaseal flow device showing physical principles.

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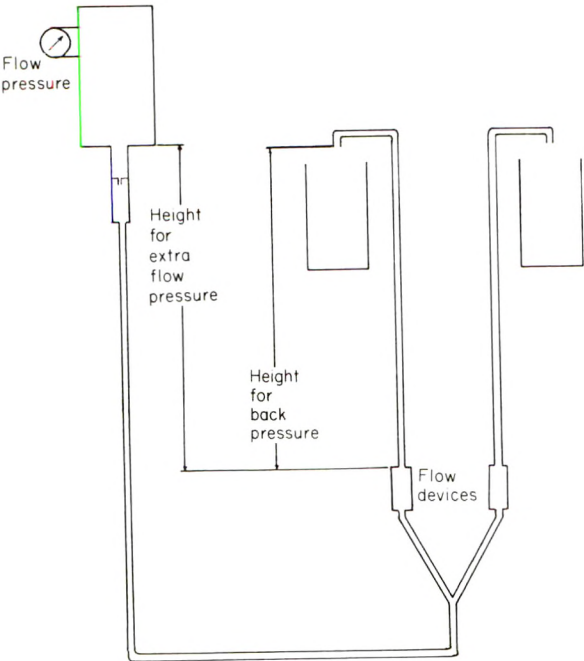


Fig. 2. Experimental arrangement that illustrates the various pressures.

Table 1. Flow values in 24 hours (ml).

Flow device	Pressure (flow-back) mmHg			
	300–70	300–7	150–70	150–7
A1	105	94	67	65
A2	90	73	58	55
B1	110	105	57	67
B2	95	90	48	57
C1	90	95	55	57
C2	75	100	55	59
D1	82	92	56	47
D2	100	110	66	57
E1	89	101	65	61
E2	89	85	48	50
Mean flow (SD)	92.5 (10.4)	94.5 (10.5)	57.5 (6.8)	57.5 (6.1)

Table 2. Mean flow values.

ml/24 hour (SD)	mmHg	Back pressure	
		70	7
Flow pressure	300	92.5 (10.4)	94.5 (10.5)
	150	57.5 (6.8)	57.5 (6.1)

Methods

The apparatus was assembled on a drip stand so that it would be portable, relatively unobtrusive and could be left in the patient area of the intensive care unit. To represent the clinical situation, the nurse in charge of the nearest patient was asked to check (and alter if necessary) the pressure in the bag (flow pressure) just as she would with the patient’s pressure line. The assembly of the apparatus on the drip stand achieved cooperation from the nursing staff since the conditions *in-vitro* were as close as they could be to the clinical situation.

The infusion solution was placed in a pressure infuser with a built-in analogue pressure gauge and inflation bulb, and hung on the drip stand at the usual height (about 2 m). The outlet tubing was then connected to two of the continuous flow devices by a Y-piece and the outputs from

these drained separately into two graduated collection vessels to measure the volumes delivered (Fig. 2).

The height of the collection vessels above the flow devices was set to create a fluid head pressure equivalent to the mean pressure encountered in either arterial or venous systems in children. This was known as the back pressure. The pressure in the infusion bag was set to 300 mmHg and 150 mmHg for each pair of flow devices (the two pressures used normally in the clinical situation). The devices were delivering their output into a back pressure of 70 mmHg and 7 mmHg at each of these flow pressures. The same five pairs of devices were used at each of the four pressure combinations and allowed to run for 24 hours, to achieve a volume that could be recorded with sufficient accuracy and to even out variations in the pressure of the infuser bag.

Results

The 24-hour flow volumes are shown in Table 1. The five pairs of flow devices are labelled A–E and the particular device of the pair designated 1 or 2. The devices maintained their specific label throughout the experiment. Table 2 shows the mean flow volumes for each group. The volume infused is proportional not to the gauge pressure but to the total pressure because of the height of the bag on the drip stand. The fluid head of pressure in the infusion tubing meant that the actual pressures presented to the flow devices were about 100 mmHg higher than the gauge pressure (i.e. 400 mmHg and 250 mmHg). These values show a direct relationship between the volume delivered and the flow pressure presented to the device.

Preliminary analysis using paired *t*-tests showed very clearly ($p < 0.001$) that the change in flow pressure produced a change in flow while the change in back pressure did not have any significant effect on flow. This calculation satisfied the primary aim of the study, although analysis of variance with log transformation of the data was carried out. This confirmed the initial analysis and showed that the variability between ‘runs’ in the study was not significant when compared with variability between devices. Therefore, concern about maintenance of the pressure in the infusion bag was unjustified and the nurses involved were obviously performing their task well.

However, the variability between the flow devices attached to the same pressure bag showed a coefficient of variation of 12% for different devices. This was surprisingly high for a standard product, and may be partly responsible for reports of high volume infusion from these devices.²

Discussion

The obvious limitation of this study is that it was not carried out *in-vivo*, because the variations of circulatory pressures might have affected the volume delivered. This would, however, have been impractical since the actual volume administered would have been difficult to calculate and because flushing of the line performed by staff would adversely affect the results obtained. However, the results have shown that the back pressure makes no significant difference to the volume infused, and so justifies the validity of the results obtained.

The results also show that reducing the flow pressure in

the infuser bag has a significant effect on the volume delivered, and so current paediatric practice is beneficial in reducing potential overtransfusion. It also draws attention to the fact that in neonates in particular a considerable fluid load can be accidentally administered especially when more than one of these devices is employed. This is also relevant in any patient on strict fluid balance.

Another practical point from the experiment is that the height of the pressure bag has an effect on the flow pressure presented to the device, and thereby influences the volume delivered. This should be taken into account, especially in paediatric practice, and the bag either lowered or the gauge pressure further reduced.

Other methods can be used to prevent accidental overtransfusion. Small volume infusion bags (50–100 ml) can be substituted though this carries the risk that the incidence of cannula blockage may be increased, because of the more frequent interruption of flow. This also heightens the risk of contamination of the apparatus and patient. Alternatively a syringe pump may be used, to allow easier calculation of volume infused. However this requires more expensive technology and generally makes the flushing procedure more awkward.

The results show that overenthusiastic use of flow devices can result in their literally becoming flush devices and caution should therefore be exercised when more than one device is used. In the neonatal field, even the use of only one device can have serious consequences and allowances must be made in fluid therapy regimens.

Acknowledgments

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Death on the table

Some thoughts on how to handle an anaesthetic-related death

A. K. BACON

Summary

This describes one way to handle the aftermath of anaesthetic catastrophe. The techniques of how to share bad news, interview relatives, complete official forms, deal with the legal process and debrief colleagues are outlined. It is hoped that this article will promote discussion on this topic and improve communication with all those affected by mishaps in the operating suite.

Key words

Complications; death.

Discussion about the emotional responses to an unexpected death in the operating suite appears to be one of the great taboos of modern anaesthesia literature. We spend years training to avoid disasters but rarely is anyone in the specialty taught how to handle them. We hope it will be something that happens to someone else, and when it does, some of us move away from that person as if we can avoid contamination with whatever it is that he or she has done. Medical education committees, seminars and articles continue to highlight themes such as monitoring, pre-operative evaluation, causes of peri-operative deaths,¹ yet there is an obvious gap in our literature. Each of us will have a number of patients who die unexpectedly on the operating table or in the recovery room during the course of our careers. It is a subject few of us want to think about. But it will happen, and when it does, we should have already given thought to how we are going to manage it.

This article explores some ways in which we can learn to anticipate the aftermath of an anaesthetic catastrophe, lessen the stresses which can be experienced, and possibly even reduce some of the needless litigation that ensues as a result of indifferent communication.

Throughout this article 'he' and 'him' are used indiscriminately, naturally accidents are not confined to one sex.

Breaking the news

The unexpected and anaesthetic-related death leaves the individual anaesthetist feeling numb or shattered. There has usually been a heroic effort at resuscitation which has failed. The surgeon may or may not have been of help during this process. He will frequently distance himself from the anaesthetist and afterwards may take it upon him-

self to go and talk with the relatives. Sometimes none of the medical team feel able to telephone the next of kin and it is left to a nurse to break the news.

The effect of this news is devastating. Place yourself in their position. Your own relative has gone into hospital for a minor operation and now there is a telephone call to say she is dead. The first golden rule is never to impart bad news over the telephone. Always ask the next of kin to come into the hospital to meet you. If they ask why, then the reply must be that there is something of great importance that you wish to tell them. If they question you further asking if there is bad news then the only possible response is 'Yes, please come to the hospital. Bring a close friend with you. I will give more information when you arrive.'

The second golden rule is that the news should be delivered by a team: the surgeon, anaesthetist, a member of the nursing staff and one or more of other professionals who may be able to help. Typically these are either an interpreter, chaplain or social worker according to the anticipated needs of the family. If any of the surgical/anaesthetic team are juniors, then the member of the senior medical staff responsible for that junior must be present, or at least provide someone of equal rank to be at the interview. Under no circumstances should the anaesthetist allow the surgeon to go in by himself. It is not unusual for a remark to be apparently misheard which triggers off great misunderstandings, interferes with the grieving process and initiates fruitless and costly legal action.

The setting for the crucial conversation needs to be thought out carefully. To do this the team should stop the operating list or hand it over to a different team. The original team must discuss who takes the lead, what resources are needed, and where the interview is to take place. The room should be about the same size as an average living

room in a house. Too large a room intimidates, as does a room that might have been a broom cupboard. The room should have carpets and chairs. It should allow uninterrupted conversation away from 'phones that ring, and accidental visitors. Such a room may normally be used as a meeting area in administration. The need for the paramedical services has to be considered and even at night the full team should be assembled.

The format of the interview

The third golden rule is to follow a plan of conversation. Obviously this can only be a generality, specifics are out of the question. The general plan covers breaking the news, giving the facts, allowing ventilation of emotions and grief, answering questions, restating the facts, outlining the steps that have to be taken by law, and finally expressing continuing support for the family and sympathy with them in this time of tragedy.

The leader in the conversation is not necessarily one of the original team. Anaesthetists and surgeons tend to have little experience or training in such conversation unless they have been heavily involved in critical care units. There can only be one leader and that person will be the principal communicator. Whoever takes the lead needs to start by confirming the identity of the relatives to whom they are talking. Many a tragic error has been made by not observing this simple protocol. The leader should introduce himself, and briefly indicate that others present are 'members of the hospital staff'. Details of who is who are unlikely to be remembered in such a stressful situation.

The worst news should be given first. The relatives know that there is bad news coming, otherwise they would not have been asked to meet with the team. The bluntness of the message can be helped a little by an introductory phrase such as 'I am afraid I have very bad news for you—despite all we tried, your wife has died.' This conveys all that you want to say. Sympathy, great effort, tragedy. The resulting effect of this statement then depends on cultural background. The aim of the next 5 minutes should be to talk facts after suitable expressions of sympathy, either spoken, or demonstrated by holding or touching the next of kin. The leader needs to start this phase by saying something along the lines of 'I would just like to talk through what has happened, and perhaps you could tell me what you knew about why she was having the operation?' This establishes a baseline of knowledge. Never assume anything. I have heard relatives claim in court that they were totally unaware that the deceased was going to have an anaesthetic or operation.

Now the picture can be built up: the nature of the presenting disease, concomitant problems, effects of medication, succinct phrases to highlight the story. Then a very brief account of what happened in the operating room, what was the principal problem encountered, an indication of the heroic efforts made by the team, an admission of 'loss'. Use phrases like 'collapse, heart stoppage, poor circulation, breathing difficulty', if it is uncertain what has happened. If you don't know, say so. 'We are not exactly sure why she died' is much better than any elaborate story which turns out to be wrong. Precise scientific explanations will be lost in the heat of the moment and may turn out to be wrong when the autopsy report is completed.

This phase of the interview should only last 5 minutes.

The relatives need emotional breathing space, time to react in private. The leader should say that he will be leaving them for about 20 minutes and then he will return. The team should then exit the room leaving only a 'carer' and, if need be, an interpreter to stay with the next of kin. The 'carer' can be anyone who is good at the task—a nurse, a chaplain, it does not matter. That person is there to sit with the family and offer practical help. They may ask if there is someone whom the relatives would like to come into the hospital to be with them. The carer can leave the room briefly to effect the telephone call, but otherwise they should not leave the room. They are not there to answer questions. Their role is to comfort, hand out tissues, let them cry and provide whatever seems to be desirable.

Final briefing of the team

The team should take this break to move to another room and discuss how the family reacted and finalise strategy for the next phase. Any last minute inclusions for the team need to be made good, and at exactly 20 minutes the team should rejoin the relatives once more. This time full formal introductions can take place. The leader then starts the process of going over what happened in the operating room. The surgeon should state what happened as he saw it if he has not taken the lead role: why the operation was needed, what was planned and similar generalities. The anaesthetist should then give a very general overview of how events unfolded, how he saw the patient on his pre-operative visit, what technique he decided on as a result of that evaluation, what happened in the theatre, once again avoiding anything too contentious or specific which later may turn out to be wrong.

There should be a pause for questions at this point. The family should be encouraged to ask anything they like. It is probable that they are still stunned by the news. The questions that may come forward may be incongruous to the team. The family need time, they need caring and they need dignity. They do not need a technical lecture on the brilliance of the performance of the operating team, or implied blame arising from some social behaviour on the part of the dead patient.

Formalities

The next stage in this interview is to inform the relatives of what happens next. Undoubtedly the Coroner's Office or similar institution will be involved. The relatives need to be aware of this. They should be told that the Coroner is the only one with the authority to do anything. He alone will check what happened and help the family in the legalities of the unexpected death. The family should contact the undertaker of their choice, and tell him that the Coroner is involved. The undertaker will then know how to proceed.

The conclusion varies. Some families ask to see the body, others just want to leave the hospital. Viewing, if requested, should take place in the presence of a member of the hospital staff to ensure that there is no interference with the body, and to explain equipment that may have been left *in situ*. On finishing, the team must offer support, a telephone number, a promise to keep in touch. The relatives should be escorted to their car, and if they came by public transport, perhaps even a lift in a car from the chaplain or social worker would show caring which will be remembered for all time.

Hospital paperwork

The next step is to go through the hospital procedures. The medical record should be checked for accuracy. Any glaring omissions or errors should be made good, but any corrections should be identified separately, initialled, timed and dated. The anaesthetic machine and ampoules used must also be examined and recorded. This process is best done by someone unconnected with the original incident. He should record the results of his checks and keep a copy for his own use. The Coroner's deposition should show facts, not opinions. Leaving it to a more junior member of staff may allow errors of interpretation. You were the anaesthetist, you should write the report. Get a friend to help you write it out, but draft it first. Let him offer constructive ways to improve the clarity of what you want to say. A provisional diagnosis is helpful but not essential.

The family doctor should be informed of the incident as soon as possible. He will not want to be in the predicament of casually meeting another member of the family, enquiring after the patient only to learn of the tragedy. The family doctor will become a key point in the care of the family after the death. It is he who will be asked for 'sleeping pills for Dad because he is not coping'. It is he who will work out that the person who is not coping is the person asking for the pills. He needs to know what is going on. Early contact with the family doctor gives the anaesthetist an ideal opportunity to pass on facts, as well as offering to relay any other information that comes subsequently to light. The family doctor then can become an ally, rather than a potentially hostile colleague who inadvertently encourages litigation.

The hospital policies must be followed. Usually the anaesthetist has to notify the incident to senior administration. An incident form or similar documentation is required for notification to hospital insurers. This, once again, requires fact not opinion. Two copies should be retained, one to be sent to the medical defence organisation as well as one for personal use. By this time the anaesthetist may well feel fed up or embarrassed by the whole incident. The colleague who came to help with the checking of the anaesthetic machine could now help with the remaining formalities. These may include notification of a state-authorised confidential enquiry committee or a departmental 'deaths and complications meeting'. The individual needs support at each stage; he is very vulnerable. The pressure of trying to maintain a semblance of normality during daily tasks can produce stresses which need a caring friend. The colleague should also find time to inform the anaesthetist's spouse or partner of what has happened, and to offer further support. The strength of this relationship will be a crucial factor in the maintenance of the mental health of the anaesthetist.

The legal formalities all take time. An inquest may be opened to allow the process of law to start; almost certainly it will be adjourned to a later date. The law is slow. Individuals vary in their response to this waiting period. Some have a private dread that they will appear on television newsreels entering or leaving the court; others bury their head in the sand, pretending that 'since I was not at fault, why should I worry?' Usually there is no more than a hint of civil litigation until the Coroner's Inquest has been held. The prudent anaesthetist consults with his defence organisation on procedures to be followed before the inquest. His

own experience to date may have been limited to a brief appearance as a first year graduate many years ago at an inquest on a victim of a motor accident who was brought into the emergency department and died soon after arrival. Now he is expected to give an account of his actions which will be examined in an environment not likely to make him feel comfortable. Rehearsal of evidence, consultation with defence organisation solicitors, sensible medical colleagues who have undergone similar ordeals or who provide expert opinion for court cases will be of the utmost help to reduce anxiety so frequently encountered by those who do not prepare themselves.

The family

The parting words to the family provided a telephone number to keep in touch. The anaesthetist should take part in this process. He may feel he lacks the skills to do this; he may feel so guilty that he does not want to see them again. He should make a point of meeting the social worker or chaplain who is the contact person if this is so. Should the relatives visit the hospital for any reason, the anaesthetist ought to make a point of meeting them at that time in the presence of the social worker. A caring attitude goes a long way to defuse legal proceedings as well as actually helping the grieving process.

Preparation for civil proceedings

The potential for legal action should never be underestimated. The problem is that you can never remember all the facts years later when it comes to court. The various freedom of information acts have made record keeping in a public institution very uninformative. The very sharp perception of events on the day diminishes with time, so that even a week later some facts are blurred. It is obvious therefore that the best time to record the facts in full is within a very few days of the event. I recommend that the anaesthetist writes out a draft of everything he can remember. Then, using the long suffering colleague once again to edit the draft and ask pertinent questions to highlight points that have been taken for granted as common knowledge, a final version can be printed which records everything in anticipation of legal action. This private record should start with the statement that it is written to assist in defence of anticipated legal proceedings. This then establishes it as outside the realm of documents that can be revealed by freedom of information acts. It must show every minute detail of the routine followed for this particular patient: when the patient was first seen, where, what was prescribed, what investigations were needed, what the results were, what your plan for the anaesthetic was, where the induction took place, who was with you at the induction, and so on. In short, everything that you know now but when asked in 2 years' time you will not be able to remember at all. Most of our routines are so automatic that we forget we even did them, writing down the boring minutiae in pedantic detail now will save endless hours of anxiety later. This document is crucial. It should be dated once completed, your signature witnessed, and a copy kept in a very safe place. Discuss its existence with your medical defence organisation, but do not forward a copy unless asked. With luck you will never need it again, but if you do, you have it there to hand.

Debriefing the theatre team

So far we have concentrated on the aspects of the catastrophe that affect the doctors and the relatives. Now we need to look at the others who were present at the time it all happened. The nursing and technical staff present may feel just as upset as you. If so they need assistance. They may need to be debriefed. Mitchell² has described a formal process of critical incident stress debriefing for emergency service personnel, which has obvious applications in the situation we face here. He recommends a defusing immediately after the event, to be followed within 2 or 3 days by a structured debriefing if this is necessary. The defusing is a simple, short meeting at which accurate and specific information is given to all on what happened and what steps are being taken to look after the relatives, or prevent similar episodes if that is relevant to the scene. Support is offered to the staff, together with a statement that anyone who wishes to talk things over is welcome at any time. 'If you are losing sleep, getting short tempered, hitting the bottle, or whatever, that may be normal and one way of coping. If it goes on for more than a few days come and knock on my door, have a chat.'

There may be no need for a formal debriefing, but when the case fits one of the following categories a 'critical incident stress debriefing' should be considered. These categories are: unusual media coverage; the patient who was a member of the theatre team; a case charged with profound emotion such as a child or patient with whom the team identify strongly; a case in which the circumstances are so unusual as to produce a high level of immediate or delayed emotional reaction.

The debriefing format recommended by Mitchell is that all who were involved are required to get together to go through a confidential group session. The leader for the session is a specially trained mental health professional, assisted by one or two peers from the affected service. The session opens with a policy statement on confidentiality at the meeting, and an overview of the way that the meeting will be conducted. Each person is then invited to say in turn what he or she was doing there, what their job was, and what they saw. Feelings are not encouraged on the first round. The first person is invited to volunteer his feelings when the first round is completed. This may not release much emotion, but perhaps somewhere around the group it might. If so, many feelings of resentment or personal dread may come to light which could cause the individual to function inefficiently in the future or perhaps to resign from the post. The group are now steered

through a recovery process which concludes the session with appropriate advice on recognising and dealing with stress.

Conclusion

This article is a follow-up to a seminar held by the Victorian Regional Committee of the Faculty of Anaesthetists, Royal Australasian College of Surgeons in Melbourne, Australia in March 1988. A great deal of thought has modified the brief version that is in press³ since the original meeting. This article started with reference to taboos, talking about the one thing we rarely talk about ourselves. We evolve coping mechanisms as individuals which, it is hoped, carry us through these moments of supreme stress. It is inevitable that some of us will need help.⁴ All of us should be aware of how to get that help should we find our defences laid waste by a tragedy in our professional lives.⁵ Each one of us needs to develop an awareness of the vulnerability of our colleagues; the suicide of a colleague is a personal tragedy as well as a waste of the resources of the community.⁶

Acknowledgment

Many sources have played a part in the genesis of this article. Its basis is the experience gained from 20 years in critical care and anaesthesia, together with numerous discussions with colleagues, lawyers, social workers, padres, psychologists and psychiatrists in congenial surroundings when the pressure of work is remote. In particular I would like to thank Dr J. Munro, Dr F. McNabb and Professor J. Mitchell for their talents in communicating ideas and practice.

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Forum

Pre-operative assessment of anxiety and measurement of arterial plasma catecholamine concentrations The effect of oral β -adrenergic blockade with metoprolol

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Summary

A double-blind study of 40 patients who underwent elective hysterectomy was conducted to evaluate the role of arterial plasma catecholamine concentrations as an objective index of anxiety, and to assess the effect of pre-operative oral treatment with a beta-adrenoceptor blocking drug. The patients were premedicated with diazepam and either metoprolol or placebo 2–3 hours before surgery. The effect on anxiety was evaluated by the anaesthetist and by visual analogue scoring by the patients. Using pooled data, a significant decrease in both adrenaline and noradrenaline concentrations was demonstrated after premedication, but no difference was found between the groups. In general, patients were less anxious after premedication, but patients who received metoprolol had greater relief of anxiety ($p = 0.0007$). A significant change in perceived anxiety was found in patients who received metoprolol, but there was no significant change in the placebo group. The correlation between the observers' assessment and the patients' visual analogue scores was poor, but some correlation was found between the assessed relief of anxiety and the changes in visual analogue score. We could not demonstrate any correlations between anxiety and catecholamine concentrations, between relief of anxiety and changes in catecholamine concentrations, or haemodynamics and catecholamine concentrations.

Key words

Premedication; diazepam, metoprolol.

Sympathetic nervous system; beta-adrenergic antagonists.

In general, the primary aims of premedication before anaesthesia and surgery are to prevent or reduce the side effects of anaesthetic agents, to relieve anxiety and to produce sedation. Relief of anxiety is believed to be of most importance.^{1–3} There are few comparative data on the relative merits of drugs used for premedication; this is due in part to the different criteria by which the desired effects of these drugs are assessed and the difficulties in measuring sedation and apprehension.^{4,5}

Young, nervous or anxious patients may have high sympathetic tone, which may result in tremor and relative tachycardia before surgery and arrhythmias during induction of anaesthesia. Increased sympathetic tone is undesirable particularly in elderly patients and those with ischaemic heart disease.

Several methods have been described to assess sedation and anxiety. These include linear analogue scales completed by the patient,^{3,6} assessments by the anaesthetist^{2,3,5} and objective methods such as measurement of plasma catecholamine concentrations,⁷ or urinary catecholamine excretion.^{8,9} The correlation between these methods seems to be poor.

Several studies have shown that β -adrenergic blockade is an effective means to reduce tremor and anxiety caused by stage fright in musicians^{10,11} or by the stress of examinations.^{12,13} Others have shown that β -adrenergic blockade reduces arrhythmias during anaesthesia.^{14–16} The effect of β -adrenergic blocking drugs on plasma catecholamine concentrations is not well defined. It might be expected that

plasma concentrations would be unaffected by these drugs. However, if there is feedback control on the receptors, blockade would be expected to be accompanied by a compensatory rise in plasma catecholamine concentrations. Conversely, a β -adrenoceptor blocker may lower catecholamine concentrations in anxiety because the drug interrupts the vicious circle whereby anxiety produces somatic effects and the awareness of such effects results in increased anxiety.^{7,17}

We observed in an earlier study of hypotensive anaesthesia¹⁸ that patients who received metoprolol appeared to be less anxious before induction of anaesthesia.

The present study was designed to investigate whether anxiety associated with the period before operation is accompanied by changes in plasma catecholamine concentrations, and whether β -adrenergic blockade has any influence on anxiety or catecholamine concentrations.

Methods

Forty patients (ASA grade 1 or 2) who presented for elective hysterectomy were randomised into two groups. None of the patients was suspected to have cancer. Age, height, body weight, arterial pressure and heart rate, together with details of current medication, were recorded for each patient. All patients gave informed consent according to the Helsinki II declaration and the study was approved by the local scientific ethics committee.

Premedication was administered orally 2–3 hours before

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surgery. The patients received either metoprolol 100 mg or placebo together with diazepam 15 mg, which was given to all patients for ethical reasons. The selective β_1 -blocker metoprolol was used in order to avoid unwanted effects of β_2 -receptor blockade. The drugs came from coded, individual boxes, and were alike in colour and shape. The observer had no knowledge of whether the patient received metoprolol or placebo. Evaluations, measurements of haemodynamics and blood sampling were carried out in the ward before premedication and in the anaesthetic room before induction of anaesthesia.

Anxiety and sedation were evaluated by the anaesthetist using a modification of a method described originally by Dundee *et al.*⁵ The degree of sedation was graded as good (2 points); fair (1 point); or slight or nil (0 point). The degree of anxiety, after assessing and questioning the patient, was assessed before and after premedication as nil (0 point), slight (1 point), moderate (2 points) or marked (3 points). All assessments were performed by the same anaesthetist. In addition, the patients were asked to rate their perceived anxiety on a visual analogue scale (VAS), which comprised a 10-cm line, the ends of which represented total calm and extreme anxiety.

Arterial pressure and heart rate (HR) were measured by a noninvasive oscillotonometric method. Measurements were obtained after the patient had rested in the supine position for at least 15 minutes; the mean of three measurements obtained during a 15-minute period was recorded. Subsequently, a sample of blood was obtained from the radial or femoral artery; local anaesthesia was not used before arterial puncture. Each sample was transferred immediately into a precooled 'Vacutainer' that contained heparin. After gentle mixing, the blood was centrifuged at 0 °C before separation and the supernatant was stored at -70 °C until analysis for catecholamine concentrations using high pressure liquid chromatography with electrochemical detection.

Two-tailed Student's *t*-test, Mann-Whitney two-tailed test and Spearman-Kendall correlation coefficient were used as appropriate for statistical analysis.

Results

There were no significant differences between groups in respect of the age, height and weight of the patients (Table 1). The femoral artery was used to obtain a blood sample in five patients, three of whom received metoprolol. The data from these patients were not different from other patients in the respective groups.

Plasma catecholamine concentrations are shown in Table 2. Concentrations of adrenaline decreased after premedication in both groups, but differences were not significant either within or between groups. However, plasma adrenaline concentration decreased in a significantly larger number of patients in the placebo group (Table 3).

A significant decrease in noradrenaline concentrations occurred in both groups after premedication. No significant differences were found between the two groups either before or after premedication. There was a small but statistically insignificant decrease in arterial pressure after metoprolol administration and a significant decrease in heart rate (Table 4). Heart rate and systolic and mean arterial pressures were significantly lower before induction of anaesthesia in patients who received metoprolol than in those given placebo.

No correlations were found between cardiovascular variables, anxiety or catecholamine concentrations in either of the groups (simple regression and Spearman-Kendall rank correlation coefficient).

The assessment of anxiety and sedation made by the an-

Table 1. Details of patients. Data are expressed as mean (SD).

	Metoprolol	Placebo
Patients, <i>n</i>	20	20
Age, years	43 (7)	39 (10)
Height, cm	165 (6)	165 (6)
Weight, kg	67 (11)	63 (10)

Table 2. Catecholamine concentrations (nmol/litre). Data are expressed as median (lower and upper quartiles).

	Metoprolol	<i>p</i>	Placebo
Adrenaline			
Before premedication	0.31 (0.20–0.51)	ns	0.34 (0.27–0.48)
Before induction	0.26 (0.20–0.36)	ns	0.26 (0.21–0.41)
<i>p</i>	ns		ns
Noradrenaline			
Before premedication	1.83 (1.54–2.29)	ns	1.83 (1.59–2.42)
Before induction	1.52 (1.32–1.79)	ns	1.50 (1.41–1.77)
<i>p</i>	<0.05		<0.05

Statistic: Mann-Whitney two-tailed test.

Table 3. Changes in plasma adrenaline concentrations after premedication.

	Rising/unchanged *	Falling
Placebo	4†	16
Metoprolol	10†	10

* unchanged \pm 10%; †*p* < 0.05 (Chi-square test).

aesthetist and the patient ratings on the visual analogue scales are shown in Tables 5 and 6. In general, the anaesthetist graded the patients as less anxious before induction of anaesthesia than before premedication (*p* < 0.01), but patients who received metoprolol were significantly less anxious than those given placebo (*p* = 0.0007).

The patient ratings on VAS showed no difference between the groups before and after premedication, but the patients in the metoprolol group had lower anxiety scores after premedication, while no significant change was found in the placebo group. However, there was no significant difference between groups in respect of the percentage change in anxiety scores on VAS.

Using pooled data, all parameters showed a significant decrease from the time before premedication until induction of anaesthesia, but neither the simple regression test nor the Spearman-Kendall test demonstrated significant correlations between changes in anxiety and changes in catecholamine concentrations in either group, or between absolute values before and after premedication.

Discussion

The most appropriate drug to alleviate anxiety or apprehension pre-operatively is a matter of debate, but benzodiazepines have found wide application because of their sedative and anxiolytic properties^{1–3,6} although some studies have found little difference in effect compared to placebo.³

In the present study three methods were employed to evaluate the anxiolytic effect of premedication; assessment by observers, self-assessment by VAS and objective assessment by measurement of plasma catecholamine concentrations. As expected from earlier studies, the correlation between the methods proved to be poor.

The results of the present investigation indicate that the combination of metoprolol and diazepam seems to be superior in anxiolytic effect compared to diazepam alone, as evaluated by both the anaesthetist and perceived anxiety on VAS (anxiety significantly reduced in patients who

Table 4. Blood pressure (mmHg) and heart rate (beats/minute). Data are expressed as mean (SD).

	Metoprolol	p	Placebo
Systolic blood pressure			
Before premedication	125.5 (11.6)	ns	127.9 (15.4)
Before induction	119.5 (11.3)	0.02	130.0 (18.4)
p	ns		ns
Diastolic blood pressure			
Before premedication	77.7 (9.2)	ns	81.1 (10.8)
Before induction	75.0 (7.9)	ns	78.6 (13.4)
p	ns		ns
Mean blood pressure			
Before premedication	91.4 (8.5)	ns	96.1 (12.5)
Before induction	86.9 (9.6)	0.048	95.3 (15.7)
p	ns		ns
Heart rate			
Before premedication	76.6 (10.1)	ns	76.3 (12.4)
Before induction	68.4 (9.6)	0.002	80.7 (13.1)
p	0.012		ns

Statistics: Student's *t*-test.**Table 5.** Assessment of anxiety and sedation by anaesthetist. Data are expressed as mean (SEM).

	Metoprolol	p	Placebo
Anxiety			
Before premedication (0-3)	1.70 (0.16)	ns	1.95 (0.14)
Before induction (0-3)	0.65 (0.15)	0.0007	1.40 (0.11)
Sedation			
Before premedication (0-2)	0.20 (0.10)	ns	0.25 (0.11)
Before induction (0-2)	1.45 (0.17)	0.0017	0.80 (0.19)

Statistic: Mann-Whitney two-tailed test.

Table 6. Assessment of anxiety by patients (VAS); mm on scale, median (lower and upper quartiles).

	Metoprolol	p	Placebo
Anxiety			
Before premedication	23.5 (13.5-57.0)	ns	27.0 (7.5-50.5)
Before induction	14.0 (3.5-22.0)	ns	19.5 (9.0-26.0)
p	0.024		ns
Change	-12.5 (-36.0-0)	ns	(-29.5-+4)

Statistic: Mann-Whitney two-tailed test.

received metoprolol). This corresponds to earlier findings of studies concerning different types of anxiety, e.g. stage fright in musicians, examination nerves and anxiety before public speaking.^{10-13,17}

The catecholamine concentrations in this study correspond to some extent to earlier findings.^{7,17-20} Fell *et al.*⁷ used venous blood sampling and found greater changes in adrenaline than in noradrenaline in the pre-operative period, which could be explained by peripheral uptake of noradrenaline. It might be expected that the changes would be more pronounced when using arterial sampling, but the results are difficult to compare with earlier studies. Fell *et al.*⁷ demonstrated a rise in both anxiety and catecholamines in the pre-operative period. The overall results in the present study were a reduction in both anxiety and catecholamines; the difference may be a result of differences in drugs and dosage. The correlation between VAS and plasma catecholamine concentrations demonstrated by Fell *et al.*⁷ was not demonstrated in this study.

The general reduction in anxiety may be explained in part by the reduced plasma catecholamine concentrations interrupting the vicious circle, whereby anxiety produces somatic effects and the awareness of such effects results in increased anxiety. However, the poor correlation between anxiety and plasma catecholamine concentrations indicates that catecholamines must be only one of several factors

that influence anxiety before surgery. Ten patients in the metoprolol group had unchanged or increased adrenaline concentrations after premedication, compared to four who received placebo. The lower anxiety found in patients who received metoprolol may be the result simply of blocked receptors in 'the anxiety circle'.

The lack of correlation between blood pressure and plasma catecholamines and between blood pressure and anxiety suggests that blood pressure is a poor indicator of anxiety.

In conclusion, premedication with beta-adrenoceptor blocking drugs may be of some value, especially in young nervous and anxious patients with high sympathetic tone.

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Obstetric anaesthetic workload in a teaching unit

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Summary

The distribution of obstetric anaesthetic work through the day was examined. Workload audit and prediction are discussed with their relevance to service and training.

Key words

Anaesthesia; obstetric.

Labour ward work has a reputation as an unpredictable area for anaesthetists' duties. A recent report that concerned obstetric anaesthetic services¹ estimated an average of two or more items of work a day for anaesthetists in units with 2000 deliveries a year or more. The maternity unit at St James's University Hospital undertakes about 5000 deliveries a year and has a dedicated 24-hour obstetric anaesthesia and analgesia service with a large training commitment. During the 6 years to 1986, the epidural analgesia rate increased to 35%

Table 1. Yearly totals for epidurals and Caesarean sections.

Year	Epidurals (% of deliveries)	Caesarean sections (% of deliveries)	Epidural Caesarean sections (% of Caesarean sections)
1981	1384 (30)	377 (8)	66 (17)
1982	1300 (27)	563 (12)	134 (23)
1983	1287 (26)	663 (14)	130 (19)
1984	1347 (28)	573 (12)	203 (34)
1985	1487 (33)	572 (13)	212 (40)
1986	1663 (35)	663 (14)	284 (43)

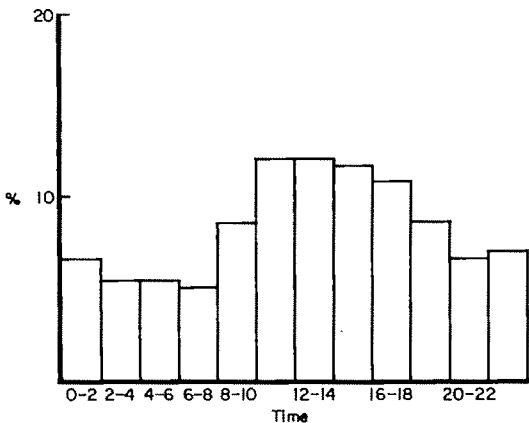


Fig. 1. Epidurals sited during each 2-hour period over 24 hours.

of maternal deliveries. In the same period, Caesarean sections increased to 14% of maternal deliveries, nearly 43% of which were performed under epidural anaesthesia. The increased demand for anaesthetists' skills has implications for service and training in obstetric anaesthesia. Also, proposals for future obstetric anaesthetic services¹ and the changes to the medical career structure outlined in the *achieving a balance* document² may require reorganisation of labour ward work for anaesthetists. In order to define priorities in this area, the timing of obstetric anaesthetic work was examined.

Methods

Anaesthetic and epidural records for the year 1986 were analysed retrospectively. The total number of mothers who

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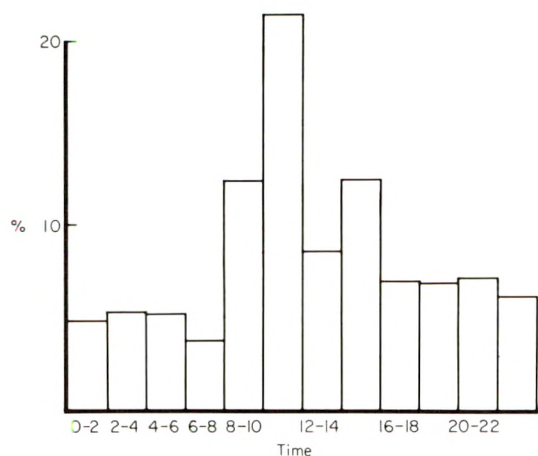


Fig. 2. Caesarean sections performed during each 2-hour period over 24 hours.

received the first dose of local anaesthetic or induction agent was recorded for each of 12, 2-hour periods, between 0000 and 2400 hours. Totals for each period during the year were compiled for routine epidurals and Caesarean sections. Items of work such as anaesthesia for retained placenta were not included for these purposes.

Results

Epidurals (Fig. 1). A slightly higher percentage of epidurals (55.7%) was performed by the on-call anaesthetist between 1600 and 0800 hours, but nearly 36% of all epidurals were sited in the 6-hour period between 1000 and 1600 hours.

Caesarean sections (Fig. 2). Three days a week are allocated for elective Caesarean sections. This influence is shown between 0800 and 1600 hours when 54.3% of all Caesarean sections were performed.

All work. Nearly half of all work was started between 0800 and 1600 hours. The period between 1000 and 1200 hours was the busiest and gradually reduced to the quietest period between 0600 and 0800 hours. The distribution of work for the three 8-hour periods from 0800 hours was 48.3%, 30.5% and 21.2% respectively.

Discussion

A distinct pattern was apparent. The busiest time was between 0800 and 1600 hours when 54.3% of Caesarean sections were started and 44.3% of epidurals sited. This large proportion of work may be explained by the presence of a consultant, often with a senior registrar or trainee anaesthetist, overlap of midwives' duties allowing more mothers with epidurals to be supervised, and the institution of specific days for elective Caesarean sections. However, analysis in this fashion may obscure particularly quiet or busy periods.

Cormack³ showed that the number of deliveries compared well with those calculated from the Poisson distribution. We used this method⁴ to predict the probability of the quantity of work for each of the three consecutive 8-hour periods from 0800 hours (see appendix). This showed probabilities of 72.8%, 75.6% and 80.9%

respectively for between one and four items of work during each of these periods. The degree of variability was shown with a 26.9% probability of no work between 0000 and 0800 hours, a 19.6% probability of five to nine items between 0800 and 1600 hours, but only a 4.5% probability of five to seven items between 1600 and 2400 hours.

Workload audit and prediction should help the training and organisation of work for anaesthetists. Trainees in obstetric anaesthesia require sufficient 'hands-on' training in a supervised environment and on-call experience compatible with daytime commitments. We do not allocate a trainee to have sole responsibility for labour ward work after a night on-call because of the large daytime workload in this unit.

Fowkes⁵ states that audit may improve clinical efficiency if the activity commonly occurs, has an important effect on the use of resources, is easily defined and examined, has an accepted standard defined by the participants and the activity is amenable to change. We consider obstetric anaesthesia fulfils these criteria but that in attempting change, implications for trainee anaesthetists should be considered.

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Appendix

Poisson distributions. These were calculated from the equation $p(n) = e^{-r}r^n/n!$ where $p(n)$ is the probability of n items of work, r the average number of items of work for that 8-hour period and e the natural logarithm.

Time 0000 to 0800 hours.	Time 0800 to 1600 hours.	Time 1600 to 0000 hours.
$r = 1.35$	$r = 3.08$	$r = 1.94$
$p(0) = 0.259$	$p(0) = 0.046$	$p(0) = 0.144$
$p(1) = 0.350$	$p(1) = 0.142$	$p(1) = 0.279$
$p(2) = 0.236$	$p(2) = 0.218$	$p(2) = 0.270$
$p(3) = 0.106$	$p(3) = 0.224$	$p(3) = 0.175$
$p(4) = 0.036$	$p(4) = 0.172$	$p(4) = 0.085$
$p(5) = 0.010$	$p(5) = 0.106$	$p(5) = 0.033$
$p(6) = 0.002$	$p(6) = 0.054$	$p(6) = 0.011$
	$p(7) = 0.024$	$p(7) = 0.003$
	$p(8) = 0.009$	
	$p(9) = 0.003$	

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Blood pressure response of neonates to tracheal intubation

The study of Drs Charlton and Greenough (*Anaesthesia* 1988; 43: 744–6) present data which we find contrary to our own experience, especially when direct intra-arterial monitoring is available. We feel strongly that this study, although well intentioned, examines the wrong physiological predictor of intraventricular haemorrhage, and can only result in the perpetuation of a practice which is increasingly regarded as rarely acceptable. It is intracranial pressure, rather than arterial blood pressure, which is likely to increase the risk of intraventricular haemorrhage.

Anterior fontanelle pressure, which correlates well with intracranial pressure, has been shown to rise substantially during awake tracheal intubation.^{1,2} These authors did not examine intracranial pressure. We suggest that flaws in study design may have prevented them from demonstrating an increase in blood pressure, as has been demonstrated in a previous study.¹ We also believe that some of their conclusions are unsupported by the data they present.

The authors explain the reason for choosing oscil-

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lotonometric methods to measure blood pressure, but this study would be more credible if they had chosen a group of neonates in whom arterial catheters were already present, or were indicated for other reasons. This would have given definitive results, and made the study irrefutable. As it is, we are surprised that, in a study to examine alteration in blood pressure, the authors only recorded the blood pressure twice in many subjects, and only three times in the others. Their results would be more believable if they had had the oscillotonometer on continuous cycling. Their pre-intubation value in the awake group was taken 'after a period of pre-oxygenation by mask'. This manoeuvre would almost certainly stimulate the infants, may make them cry, and is likely to result in an artificially elevated pressure. Similarly a 'resting' blood pressure was taken with babies 'in position for induction of anaesthesia'. It is unclear from this description whether they were being restrained in any way.

The authors give no details of duration of laryngoscopy, and this could have an effect on the pressor response. No data are available for the neonate, but it is possible that, during prolonged laryngoscopy (which is more likely in an awake neonate), there may be some accommodation to laryngeal stimulation, which distorts the blood pressure recordings after intubation. This may be compounded by the long duration of the measurement period to record the blood pressure (>30 seconds [Dinamap User's Manual]). The authors conclude that in the neonatal period, the pressor response to tracheal intubation is absent, and they suggest that it develops after one month of age. Their own data, however, show a significant increase in blood pressure in the halothane (H) group after intubation. Irrespective of the lower pre-intubation blood pressure, they did demonstrate a rise in blood pressure, which indicates the ability of this group of neonates to mount a 'pressor response' to tracheal intubation. There is no physiological reason why an awake neonate should not be capable of the same if such a response is present in anaesthetised neonates.

Few now doubt that neonates feel pain and mount an appropriate stress response to surgery.³ Most accept that we should provide adequate general anaesthesia for surgery in this age group. We believe we should also concern ourselves with providing anaesthesia for tracheal intubation in these patients, unless there are good reasons to the contrary. Awake tracheal intubation should be reserved in neonates, as in adults, for the difficult airway, or unstable or moribund patients.¹ Evidence shows that laryngoscopy and intubation in the neonate, whether painful or not, are stressful and may provoke an increase in intracranial pressure. Awake intubation should be discouraged in this high risk group.

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Replacing analgesic nitrous oxide with a dangerous alternative

Rodrigo and Rosenquist have examined the efficacy of isoflurane as an alternative for analgesic nitrous oxide for conscious sedation (*Anaesthesia* 1988; **43**: 369-75). They cite as the rationale for this trial the 'drawbacks' of nitrous oxide that is, the interference of the gas with vitamin B₁₂ metabolism which can cause myelosuppression and myeloneuropathy. However, they neglect to state that haematological changes only occur in fit patients after at least 5 hours' exposure to anaesthetic concentrations of

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A reply

We hope this group will substantiate their claims by publishing their series of continuous direct arterial pressure records of prematures, less than 4 days old (effectively the only ones at risk of intraventricular haemorrhage, IVH) awake during tracheal intubation, along with the corresponding pre- and postoperative brain scan findings.

Many of the concerns expressed by the writers relate to issues other than that addressed by our paper. It remains to be seen whether anterior fontanelle pressure (AFP) increase at awake intubation causes IVH during anaesthesia, so to describe it as a predictor is not appropriate. Our report, dealing only with blood pressures, was carefully worded and cannot reasonably be construed as a plea for awake intubation.

There are no flaws in our study design. It is pure conjecture that awake neonates accommodate to laryngeal stimulation, but precisely because of the potentially variable duration of laryngoscopy the blood pressures after intubation were timed accurately (one cycle-length) from the moment of maximal stimulation as the tube passed into the trachea. No other investigation has done this. The temporal relationship between laryngoscopy, intubation and the one-minute Dinamap cycles appears to be random in the quoted study by Friesen *et al.* Furthermore, since 'immediately after intubation . . . pancuronium and an anaesthetic were administered' we remain sceptical about the validity of the blood pressure measurement as a response purely to intubation. The same authors in an earlier study group three times this size, with a similar protocol, found no significant pressure increase.¹

The comments about pre-oxygenation indicate that the writers have missed the whole point. If blood pressures in babies after awake intubation are no greater than those in response to minor handling (pre-oxygenation) then they surely cannot be regarded as harmful. We still have seen no evidence that our neonates have been harmed by awake intubation, which, we fully agree, is only rarely indicated.

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nitrous oxide.¹ Clearly bone-marrow changes are irrelevant to conscious sedation in dentistry (or any other similar application) where exposures to nitrous oxide seldom exceed one hour. The bone-marrow changes found in the three of 20 dentists mentioned in this paper occurred in association with ambient concentrations of nitrous oxide in excess of 1000 ppm; levels much higher than are found where adequate scavenging is employed.^{1,2} The neurological changes associated with nitrous oxide only follow

chronic heavy abuse of the gas³ which is a situation hardly consistent with the routine use of the gas for conscious sedation. The relationship between abortion and exposure to nitrous oxide in dental assistants is not yet proven conclusively; inherent biases or other factors,⁴ including perhaps inefficient scavenging, may have accounted for the small increase in abortions in these females.

It appears therefore that the concern expressed by Rodrigo and Rosenquist about the safety of nitrous oxide for conscious sedation is without foundation.

Unfortunately, in contrast to nitrous oxide, a potent agent such as isoflurane carries very real dangers and disadvantages for conscious sedation. For instance, whilst it is relatively simple to titrate analgesic nitrous oxide to the patient's requirements, this is clearly not the case when one is giving fractions of a percent of an agent. This has led to one of the most serious flaws in the design of this trial. It is well known that the requirements of nitrous oxide for adequate sedation vary from 10% upwards. It is possible, for this reason, that by using a constant concentration of the gas, certain patients received more than was actually required for adequate sedation, with resultant increases in measurable side effects.

Isoflurane can, in addition, cause respiratory and cardiovascular depression and laryngospasm. Other untoward effects include the greater propensity for isoflurane to produce unconsciousness when compared to nitrous oxide, as well as its slower offset of action, which could produce problems in the outpatients.⁵ Isoflurane is also linked with increased seizure activity⁶ and feelings of depression and withdrawal,⁵ which could have serious implications for patients who have neuropsychiatric conditions. It can also decrease glucose tolerance.⁷ The unpleasant odour may be a considerable drawback in the treatment of highly anxious children,⁸ who often need conscious sedation.

Isoflurane is also extremely expensive and no dedicated equipment with a failsafe feature, which could prevent the advent of unconsciousness is, as yet, available for the administration of this extremely potent agent. Taken as a whole, it appears premature and even dangerous to replace nitrous oxide, which has an unrivalled safety record of more than a century,¹ with a relatively untried agent such as isoflurane, which has already shown serious untoward effects. 'We cannot abandon a drug because it is not perfect or completely harmless; we must be careful not to advocate more troublesome alternatives.'⁹

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A reply

Dr Gillman quite correctly states that inefficient scavenging may have accounted for some of the problems with nitrous oxide. It is true that in many parts of the world nitrous oxide is used for conscious sedation without scavenging or with relatively inefficient scavenging systems. Further, the specific lower limits of pollution with nitrous oxide which lead to problems are still not yet determined. Thus in places where scavenging is not used, or inefficiently used, if an alternative which does not produce such problems can be utilised it will be beneficial.

It is true that it may take longer to titrate isoflurane than nitrous oxide to patient requirements, and recovery may take longer, though this did not occur in our study. However, the quality of sedation was better with isoflurane.¹ Similar problems arise during intravenous sedation with benzodiazepines during induction and recovery;¹ nevertheless, this technique is still very popular. We have never stated that isoflurane is the perfect alternative.

The studies done with isoflurane show significant respiratory and cardiovascular depressions which do not occur with concentrations used for sedation,² unlike with concentrations used for general anaesthesia.^{3,4} Seizures⁵ and decreased glucose tolerance⁶ have occurred with anaesthetic concentrations and not with subanaesthetic concentrations used for sedation. The odour was well tolerated by adults in our study.¹ It is too premature to say that it will not be tolerated by highly anxious children without performing studies on them. Feelings of depression and withdrawal were reported in one study,² but we did not come across such problems in our study. This is why we have suggested that isoflurane should be further investigated for conscious sedation.

Nitrous oxide and the equipment necessary to provide it, and for scavenging, is very costly in some countries, and its use imposes the burden of changing cylinders as well as transporting and storing them. However, once isoflurane is used more widely its price may come down. No dedicated equipment is yet available for giving isoflurane for sedation, but it has been suggested that the manufacturers look into it.⁷

Dr Gillman has jumped the gun. We have not asked anybody to replace nitrous oxide with isoflurane at present, but we have suggested that of the findings in our study justify further investigation of isoflurane for conscious sedation with an aim of incorporating it into the clinical practice of sedation.

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Nitrous oxide and hypoxia: is it the gas or the user?

Moore recently made the point that the injection of an incorrect drug is, in the final analysis, the responsibility of the physician.¹ It would be considered totally inappropriate to blame the drug for any untoward effect after such a mistake, and to list as one of its major side effects or disadvantages the incorrect or inappropriate use of such an agent would be considered laughable. But in the case of one drug this is exactly what is done. Delivery of hypoxic gas mixtures where nitrous oxide is involved is considered as an adverse effect² or a disadvantage³ of the gas. Perhaps we should reexamine our attitude in this matter? It appears to me that this is a disadvantage of and (or) an adverse reaction to carelessness. Why do we continue to blame nitrous oxide?

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Pseudo-cyanosis: time to reclassify cyanosis?

We were interested to read the article about 'Argyria or cyanosis' (*Anaesthesia* 1988; **43**: 755-6) since we also had a difficult differential diagnosis of cyanosis that involved a case of argyria.

A 71-year-old woman presented with a fractured neck of femur for insertion of a dynamic hip screw. She had suffered severe rheumatoid arthritis for years and had been treated with a regimen of steroids, hydroxychloroquine and sodium aurothiomaleate. Her blue facial discoloration was immediately obvious, but she had not noticed any change. Her cardiovascular and respiratory system appeared normal; her nail beds, tongue and lips were pink. Routine investigations of full blood count, serum urea and electrolytes, electrocardiography and chest radiography were normal. Arterial blood gas analysis (Fio₂ 0.30) showed a saturation of 99.4%; pH 7.39, PCO₂ 3.82 kPa, PO₂ 21.8 kPa, HCO₃ 21.8 mmol/litre, base-excess -1.2 mmol/litre.

An uneventful pre- and postoperative course followed spinal analgesia using 0.5% isobaric bupivacaine 2 ml with monitoring of pulse rate, blood pressure, electrocardiography and arterial oxygen saturation by pulse oximetry.

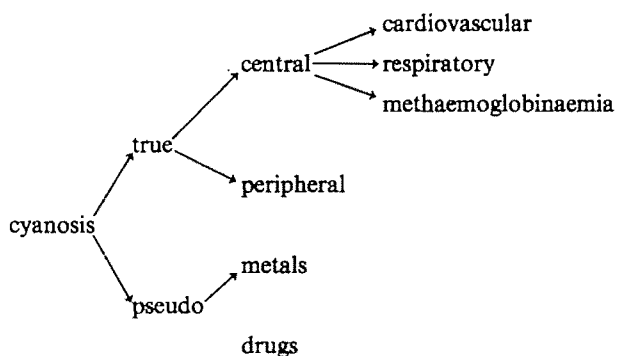
Chrysis¹ is defined as a grey, blue or purple pigmentation of light-exposed areas. It is a rare but dose-dependent complication of gold treatment which tends to be permanent. This is well recognised in our rheumatology department and can be incorrectly diagnosed as cyanosis.²

We would like to add this cause of blue cutaneous discoloration which mimics cyanosis to those already mentioned by Timmins and Morgan. In addition, we believe that there is now a basis to reclassify the causes of cyanosis into true and pseudocyanosis. True cyanosis may be central, including cardiovascular, pulmonary causes and methaemoglobinaemia and (or) peripheral due to high tissue oxygen extraction. Pseudocyanosis results from grey, blue or purple cutaneous pigmentation, the causes of which include metals^{3,4} (haemachromatosis, gold, silver, lead, arsenic; drugs⁵ (phenothiazines, minocycline, amiodarone, chloroquine).

In summary, we have performed a detailed history,

examination and adequate investigation, so that the classification (see below) would undoubtedly help clarify the differential diagnosis of 'cyanosis and the blue face'. Few general medical textbooks contain such a classification, so would this be a 'golden' opportunity to put the matter straight?

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Skills in basic life support

The article by Rees and Willis (*Anaesthesia* 1988; 43: 347-9) prompts me to report the findings of a recent questionnaire study on resuscitation that was conducted at St Helier Hospital amongst the nursing and midwifery staff.

Questionnaires were sent to 250 nurses (sisters and staff nurses) and to 100 midwives.

Eighteen percent of nurses had received basic life support training in the last year, and for the majority it was more than 5 years since they had training. Thirty-four percent of nurses were taught by an anaesthetist how to ventilate a patient's lungs using mask and airway, and only 36% of them felt confident to do this. No midwife had received basic life support training in the last year, and for the majority their training was more than 5 years ago. Forty-one percent of midwives knew the correct posture for the resuscitation of a pregnant woman and 47% said that they had ventilated a patient's lungs using a mask and airway. However, only 32% said that they would be confident to perform this during an emergency.

Early initiation of effective cardiopulmonary resuscitation improves survival from cardiac arrest.¹ There are obvious shortcomings in the provision of effective cardiopulmonary resuscitation when only approximately one in three nurses, who may be in charge of a ward, or one in three midwives managing a patient in labour feel confident about ventilatory techniques.

The problem of a cardiac arrest in the labour ward is (fortunately) a rare occurrence. There is an increased need where an epidural service is offered for the midwives to be able to provide basic life support while they await the arrival of an anaesthetist, when total spinal blockade has developed, or when convulsions occur.

There thus exists a clear requirement for regular training and practice in the provision of cardiopulmonary resuscitation. This small survey indicates that we are falling short of these ideals, and that improved training in basic life support techniques is a necessity in the general as well as on the labour ward.

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A reply

Thank you for asking us to comment on Dr Langton's letter.

We agree there is a clear need for the provision of regular training and practice in cardiopulmonary resuscitation for nursing and midwifery staff in maternity units since half the maternal deaths in England and Wales are the result of acute causes associated with present day obstetric conditions and procedures.¹

It is not surprising, although it is very unsatisfactory, that 41% of the midwives knew the correct position required for the successful resuscitation of the pregnant woman. The most recent recommendations of the American Heart Association in their standards and guidelines for cardiopulmonary resuscitation make no reference to pregnancy.² The third edition of *Cardiopulmonary cerebral resuscitation* by Safar and Bircher, 'An

introduction to resuscitation medicine prepared for the World Federation of Societies of Anaesthesiologists' fails to make any mention of pregnancy although the text refers to every other diverse circumstance imaginable in which resuscitation might be required.³ The only publication in British journals until recently that outlined the problems of pregnancy was a report of the Royal College of Physicians.⁴

There is a need for the dissemination of information about the peculiar problems associated with the resuscitation of the pregnant woman to all medical nursing and ancillary staff.

In a reassessment in Cardiff of 57 midwives who had been trained in Basic Life Support, a comparison was made between the percentage of midwives who ventilated and applied external chest compressions correctly to a manikin in the supine position and with the mannikin inclined on the Cardiff Wedge. The results are summarised in the Table. There are increases in the percentage of

Table 1. Percentage (SEM) midwives who performed Basic Life Support correctly (n = 57).

	Supine	Inclined	
External cardiac compression	62.6 (2.7)	70.2 (3.2)	p = 0.06
Ventilation	70.4 (3.4)	77.4 (2.7)	p = 0.03

midwives who applied ventilation and chest compression correctly in the inclined compared with the supine position; that for ventilation was statistically significant (paired *t*-test). These results show the value of regular practice and reassessment in the maintenance of resuscitative skills and also that the Cardiff Wedge, which maintains the patient in an appropriate position to be resuscitated, proves no detriment to the resuscitative procedure.

In the context of providing epidural analgesia in labour, we trust that Dr Langton's statement 'waiting for the arrival of the anaesthetist' means 'resident anaesthetist'. A maternity unit that does not provide a resident anaesthetist exclusively for that unit is substandard.⁵ Unfortunately in the United Kingdom many maternity units fail to provide this level of care. The financial cost of failing to provide such a service is graphically illustrated in the latest Medical Defence Union Report.⁶

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Midazolam, hypotension and neurological sequelae

The case reported by Drs Matson and Thurlow (*Anaesthesia* 1988; **45**: 896) is interesting but begs further analysis in the light of reported evidence. The observed decrease in blood pressure would be more statistically than clinically significant in a healthy adult. The neurological sequelae reported are more worrying. In an otherwise healthy, elderly patient this seems to be somewhat surprising given that such patients have a normal cerebral blood flow¹ and that autoregulatory responses are maintained in most subjects with cerebral atherosclerosis.² Indeed, even in the case reported, the fall in blood pressure lies well within the range for cerebral blood flow autoregulation. Furthermore, in patients (ASA 1–2) with brain tumours, cerebral perfusion pressure is maintained on induction of anaesthesia with midazolam, using doses in the order of 0.25 mg/kg.³ However, autoregulation may be abolished in areas surrounding brain tumours⁴ and this leads to a passive dependence of blood flow on mean arterial pressure in such areas: even small decreases in blood pressure may then lead to intracerebral steal and regional ischaemia.^{4,5} This seems to be the most likely explanation for the observations in the case reported. In our experience, of more than 1000 patients, who have received intramuscular midazolam (as part of a balanced sedo-analgesic technique for urological procedures) there have been no recorded cardiopulmonary or neurological complications (one third of the patients were aged over 70 years and 17% were ASA 3).

We agree that the increased sensitivity of some elderly patients to benzodiazepines demands a reduction in dosage in this age group. However, although the observations of Drs Matson and Thurlow are interesting, they need to be placed in their proper clinical context. Whilst, perhaps, special care should be taken when using a benzodiazepine

in the elderly subject with a brain tumour if rare instances of neurological sequelae are to be avoided, for other patients in this age group midazolam remains a safe and effective premedication agent. Given the clinical concern in this case, it would have been appropriate if flumazenil, a specific benzodiazepine antagonist which should now be readily to hand in all situations where these drugs are in regular use, had been available to reverse the untoward effects of the administered premedication.

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Anxiety and informed consent

We recently read the article by Antrobus (*Anaesthesia* 1988; **43**: 267–9) with much interest but about which we would like to make the following comments.

The author purported to investigate whether or not surgical patients with high anxiety levels before operation were more likely to withhold consent for inclusion in premedication studies than those who were less anxious. In doing so, the author first assessed pre-operative anxiety with the help of two questionnaires, and thereafter requested the patient's consent without knowledge about questionnaire results. Anxiety, however, is known to be associated with specific verbal and nonverbal behaviour patterns such as trembling, perspiration, rigidity of posture, and other psychomotor expressions. It is therefore possible that each patient's anxiety was perceived unconsciously as such by the author, and thus influenced (again unconsciously) the way in which he requested consent. Patients who display high levels of anxiety may thus withhold consent, not because of level of anxiety, but because consent is requested in a different manner. These types of experimenter effects were first described in the behavioural sciences by Rosenthal¹ in the early sixties.

Our second comment is about the use of the correlation coefficient as a measure of agreement between the two methods of assessing anxiety. Agreement cannot be assessed by a correlation coefficient; weighted kappa would be a more appropriate index of agreement.²

Finally in Tables 1 and 2, in which the type of surgery is considered the author states '... there was no significant difference in the number who granted consent for inclusion in the ... study ... when patients who had major surgery

were compared with those with minor or intermediate surgery ...'. He goes on to conclude '... patients with high levels of pre-operative anxiety ... are more likely to withhold consent ... than are those with less anxiety'. Inspection of Table 2, however, reveals that seven out of 10 patients in Group B had major surgery, whereas in Group A only 14 out of 33 patients did so. Indeed, this difference is statistically not significant, but the author is mistaken in his reasoning that the type of surgery cannot have contributed to the decision whether or not to grant consent. Since only 10 patients in Antrobus' sample actually withheld consent, differences in intervening variables, such as type of operation, had to be so extreme to reach statistical significance (in his case: at least nine out of 10 in Group B with major surgery) that only one conclusion remains: more patients should have been included in the study.

What inference can be drawn? It seems that patients who have major surgery, who show high levels of pre-operative anxiety, are indeed more likely to withhold consent than are those patients with less anxiety. No conclusions can be drawn from this study in connexion with minor/intermediate operations. Nine out of 12 patients with minor/intermediate surgery and a high level of anxiety did grant consent. This leaves an investigator who wanted to study the effect of anxiolytic premedicant drugs with a substantial number of anxious patients if he or she chose these kinds of operations. Our advice would be not to jump the gun and abandon the informed consent policy in studies of premedication and anxiety, but to be sure not to include patients undergoing major surgery instead.

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A reply

Thank you for the opportunity to reply.

It was recognised in advance that the manner in which informed consent is sought can influence the response, and for this reason the interview was carefully structured and rehearsed. It is, of course, possible that the author subconsciously perceived anxiety and unintentionally influenced the patients by nonverbal means, to withhold consent. However, the fact that nine out of 12 patients who had minor/intermediate surgery with a high level of anxiety did grant consent might suggest that this was not the case.

The possibility that different aspects of anxiety were elicited by the two methods of assessment was considered.

The degree of correlation observed suggests that they were varying in a qualitatively similar fashion.

The decision to grant or withhold consent involves many factors, and the type of surgery may contribute. An attempt was made to assess the relative importance of the measured variables based on the available data. The observed difference in anxiety achieved statistical significance while the type of surgery did not, as was reported.

Jelicic *et al.* suggest that patients who have major surgery should be excluded from studies of premedication and anxiety because they are more likely to withhold consent, but these are the patients generally thought to need premedication most. The proposed alternative, to study patients who face minor and intermediate procedures and who, despite high anxiety scores, grant consent, would not be a valid model on which to evaluate premedication for major surgery.

Your correspondents' caution about abandonment of the consent procedure is endorsed, but I suggest that anxiety be measured before consent is obtained. Anxiety scores for patients who enter the study and those excluded could then be compared.

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J.H.L. ANTROBUS

Body temperature during cardiopulmonary bypass

We read with interest the recent paper (*Anaesthesia* 1988; **43**: 181–5) by Drs Bone and Feneck on bladder temperature as an estimate of body temperature during cardiopulmonary bypass.

We have been using bladder temperature monitoring in our institution since 1983 for all cardiac patients both during and after operation. Our observations¹ with minor differences are similar to those of Bone and Feneck intra-operatively. The baseline oesophageal temperature in the group of patients we studied was slightly greater than the bladder temperature. The bladder temperature lagged behind the oesophageal and nasopharyngeal temperatures during cooling on cardiopulmonary bypass, and it was closer to and higher than the rectal temperature. The bladder temperature lagged behind the oesophageal and nasopharyngeal temperatures during rewarming but remained higher than rectal temperatures. The skin temperatures lagged behind the rectal temperatures during rewarming.

We agree with the conclusion of the authors that the bladder temperature is a convenient method of core temperature monitoring. The lag time in the changes in temperature of the bladder during active cooling and rewarming have to be remembered. However, our observations on the skin temperatures monitored over the great toe are different and we consider that the skin temperature is unreliable for the monitoring.

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Reference

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A reply

We thank Professor Moorthy for his interest in our paper.

Patterns of temperature change are of interest in all patients in whom body temperature monitoring is important, and our study was designed to compare more conventional sites with bladder temperature changes. Our own data suggest that, of the sites studied, bladder temperature is closest to rectal temperature both in its initial value and in its pattern of change during cooling and rewarming. We certainly agree that the oesophageal and nasopharyngeal sites cool and warm more quickly, and that there is therefore a lag time in bladder temperature change which may be important.

We were not surprised that skin temperature at the thumb was lower than at all other sites at baseline, and there was greatest variability here also. Despite the relatively predictable pattern of temperature change seen here, we do not think that this can be considered as a suitable monitoring site when core temperature is needed, and cannot recommend it for this purpose.

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Otitic barotrauma

The letter by R. Bailie and J. Restall on otitic barotrauma in association with the use of nitrous oxide during anaesthesia. (*Anaesthesia* 1988; **43**: 888–9) was interesting.

The authors are now, on occasions, taking an otological history and assessing the appearance of the tympanic membranes in order to decide whether there is a significant degree of Eustachian dysfunction present. The appearance

of the tympanic membrane can, however, be rather misleading when attempting to assess the state of the Eustachian tube. This may result in some patients being placed in an 'at risk' group when in fact they are not, or of course the reverse may occur.

The use of impedance audiometry may help. It is a fast and cheap investigation to perform and the facilities are

usually readily available in every hospital with an ENT Department. It will reveal those patients who have a significant degree of Eustachian dysfunction and thus help to define those definitely at risk of otitic barotrauma. It might also, on occasions, remove patients from this 'at

risk' group and thus allow anaesthetists more latitude in their choice of anaesthetic agents.

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G.J. MADDEN
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Accidental femoral nerve block during local anaesthesia for inguinal hernia repair

Inadvertent block of the femoral nerve during local infiltration anaesthesia for inguinal hernia is an unusual complication. Lewis and Fell reported two adults with this problem following ilio-inguinal and iliohypogastric nerve block to supplement general anaesthesia¹.

Ninety percent of my adult inguinal hernia repairs are performed in an ambulatory facility under local anaesthesia with intravenous sedation and monitoring by an anaesthesiologist. The anaesthetic mixture is equal parts of 0.5% bupivacaine and 1% lignocaine with 1:300 000 adrenaline. The total volume used is between 25 and 50 ml.

The block is performed in incremental stages so that the nerves are injected directly through the external oblique aponeurosis. This blocks the ilio-inguinal and iliohypogastric nerves and the anterior branch of the twelfth thoracic nerve. The genital branch of the genitofemoral nerve is selectively blocked behind the spermatic cord before it is transected with the external spermatic vessels.

During the period from March 1972 through September 1988, I performed 4384 adult inguinal herniorrhaphies under local anaesthesia. In five instances an inadvertent femoral nerve block occurred and the patients were unable to walk. The motor paresis lasted from 40 minutes to

2.5 hours. The complication did not prevent the patients' discharge on the day of surgery.

The femoral nerve supplies the pectineus, sartorius and quadriceps. It enters the thigh under the iliac fascia just lateral to the anterior femoral sheath and adjacent to the femoral artery. Its trunk promptly divides into numerous branches in the femoral triangle.

There is no point where the nerves blocked in hernia repair are in close apposition to the femoral nerve. However, if the anaesthetic agent is deposited deep to the iliac fascia it might produce a femoral block by diffusion as suggested by Lewis and Fell.

Careful attention to the site of the needle when blocking the ilio-inguinal nerve is important. In addition, the use of a small amount of adrenaline will help limit the extent of diffusion at the local depot sites.

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Reference

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Insulation of needles

Dr Pither's letter (*Anaesthesia* 1988; 43: 991) raises some interesting points.

Firstly, he quotes me out of context. Had he paraphrased the last sentence of my letter fully¹ he would have included the caveat that uninsulated needles used inappropriately or by the inexperienced may result in penetration of the nerve by the needle before maximum stimulation of the nerve occurs. This was written after the report by Dr Frerk² of two patients whose femoral nerves were damaged, possibly as the result of intraneural injection or direct nerve damage when uninsulated needles were used. It may be that if insulated needles were to be used then these complications would not have occurred.

Unfortunately I cannot find any data which compare the incidence of nerve damage after the use of insulated or uninsulated needles (others may know of such reports), but I have no doubt that Dr Pither, who is associated with

seminal work in this field, has the experience and depth of knowledge to minimise such damage when he uses uninsulated needles. However, not all anaesthetists are as fortunate as he and it is for this reason that I suggest that where possible insulated needles be used with nerve stimulators especially by the inexperienced or, as Dr Frerk points out in his reports, when blocks are being performed under general anaesthesia.

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Anaesthesia for emergency Caesarean section using the Brain laryngeal airway

We report the use of the Brain laryngeal mask airway¹ after failed intubation at Caesarean section.²

A 31-year-old, para 2⁺¹ woman was admitted at 2300 hours to the delivery unit with severe pre-eclampsia at 31 weeks' gestation.

A phenytoin infusion and hydralazine for control of blood pressure was started to prevent seizures. She was transferred after stabilisation to theatre for Caesarean section where, in view of an apparent low platelet count (an erroneous result) and patient preference, general anaesthesia was chosen. There was no gross facial oedema or difficulty with mouth opening. She had full dentition and capped upper incisors and canines.

Thirty millilitres of 0.3M citrate was administered orally followed by Holdsworth roll, and pre-oxygenation commenced with the patient on a right lateral wedge. Induction was with thiopentone and suxamethonium and cricoid pressure was applied.

The posterior aspects of the arytenoids were visible on laryngoscopy but it proved impossible to pass a tracheal tube. The patient became cyanosed and further attempts were abandoned; 100% oxygen was administered until spontaneous ventilation returned.

Auscultation of the fetal heart showed severe bradycardia and the obstetricians asked to proceed. Halothane and 50% nitrous oxide-oxygen was introduced. A size 3 Brain

laryngeal mask was inserted easily and an excellent airway achieved. The infant was satisfactory and the patient made an excellent recovery with no recall, but she had a sore throat afterwards.

One of the authors of this letter had become familiar with the use of this airway before use in this emergency. It is recommended that such experience is obtained and that the rules of failed intubation at Caesarean section should still apply.

A narrow escape from epidural anaesthesia?

A 38-year-old woman was admitted because of minor antepartum haemorrhage at 33 weeks of her first pregnancy and, after spontaneous rupture of membranes, she went into preterm labour. An epidural anaesthetic was requested by the obstetric team. The patient reported that for 30 minutes she had experienced paraesthesia of the right hand spreading to the right arm, face and tongue as the duty anaesthetist was preparing to give the anaesthetic. This was accompanied by mild weakness of the right arm and fluctuating expressive dysphasia, and later by a mild bifrontal headache. Closer questioning disclosed two recent episodes of right homonymous hemianopia followed by a pounding bifrontal headache and photophobia. A diagnosis of focal migraine was made. There was a family history of migraine in both parents and two brothers, but she had never had a migraine prior to pregnancy.¹ An epidural anaesthetic was not administered. The labour continued and nitrous oxide-oxygen were administered as analgesia. Expressive dysphasia recurred intermittently, but the delivery was uncomplicated. Twenty-four hours after delivery the neurological symptoms and headache had resolved completely.

It is well recognised that epidural anaesthesia is often accompanied by hypotension. Neurological dysfunction during and after iatrogenic hypotension is also well documented, particularly in patients who have pre-existing stenoses of the cranial arteries.^{2,3}

Many neurologists consider that the focal neurological symptoms in migraine are the result of cerebral ischaemia.⁴

A modified coaxial system for use with a circle absorption system

It is logical, with the introduction of expensive volatile agents and a simultaneous drive towards greater efficiency and cost saving within the Health Service, to use a circle system whenever possible. There is, however, general reluctance to use this type of system whenever spontaneous ventilation is desired, possibly because of the relative simplicity of the alternative Magill or Bain systems, and because of the cumbersome nature of double lengths of black antistatic tubing which are commonly used with the absorber.

Closed system anaesthesia might be more popular if it were combined with the advantages of a lightweight coaxial system such as the Lack or Bain. Coaxial systems are not new and such a coaxial system is described for use with a Manley ventilator.¹ A similar system (Mera F circuit, Senko Medical Trading, Japan) is also available in Japan.²

We have introduced coaxial tubing connected to the absorbers of a circle system recently in our department. The system comprises a Lack system (M. & I.E. coaxial tubing) from which the valve mechanism and bag mount are removed, and the hole in the bag mount occluded with a replacement metallic cap for a Heidbrink valve (Fig. 1). The lightness and versatility of a coaxial system are combined with the economy of low flow. Resistance to low

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Occasionally, during the course of a typical migraine, patients suffer actual cerebral infarction demonstrable by CT scanning.⁵ Epidural anaesthesia was intentionally not administered to our patient because accompanying hypotension might have provoked worsening cerebral ischaemia and even cerebral infarction. In a computer-assisted literature review we have been unable to find any report of a migraine sufferer who sustained cerebral infarction in association with iatrogenic hypotension. Had our patient's migraine attack developed during epidural anaesthesia, the outcome might not have been so favourable.

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Fig. 1.

and high gas flows in this and a similar system is found to be satisfactory.³ We have used this arrangement in a

number of patients and have found no increase in end-tidal carbon dioxide levels compared with those when conventional tubing is used.

The continued use of high gas flows must be reconsidered if the new, expensive agents are to find a place in anaesthetic practice. Use of this simple device may induce some anaesthetists to alter their already ingrained ideas. A considerable financial saving may then follow.

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Phenytoin-induced resistance to vecuronium

The case report by Hicky *et al.* (*Anaesthesia* 1988; **43**: 757–9) prompts us to report a similar experience of apparent phenytoin-induced resistance to vecuronium.

A 58-year-old, 70-kg male required surgery for cholecystectomy and right hemicolectomy. Twenty-five years previously he had sustained a head injury in a road traffic accident. He developed seizures, which still occurred occasionally, and were treated with phenytoin 400 mg daily. Pre-operative physical examination was unremarkable. Routine haematology and biochemistry were normal. Pre-operative phenytoin level was 3.9 mg/litre (therapeutic range 10–20 mg/litre). Two hours before surgery, oral phenytoin 200 mg was given. Premedication administered one hour before anaesthesia consisted of papaveretum 15 mg and atropine 0.4 mg. A peripheral venous line was established and a 0.9% saline infusion started. Neuromuscular function was monitored using a Relaxograph (Datex). Anaesthesia was induced with fentanyl 100 µg and thiopentone 400 mg.

The lungs were ventilated with 33% oxygen, 67% nitrous oxide and 1% isoflurane after loss of the eyelash reflex. The Relaxograph was calibrated and baseline twitch height was obtained. Vecuronium 8 mg was injected through the free running drip. The twitch height T1% was 25 after 7 minutes and all the four twitches were visible and recordable (T1%/T4% value 25/20). A fault in the recording system of the relaxograph was suspected. Tracheal intubation was attempted, but the cords were still moving. Intubation was only achieved with difficulty. Five minutes after the start of surgery and a total of 12 minutes since the bolus injection, T1% was 35 (T1%/T4% value 35/10). The patient breathed out-of-phase with the ventilator. A supplementary dose of vecuronium, 2 mg was injected (Fig. 1).

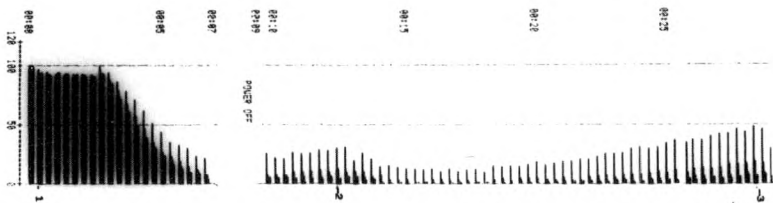


Fig. 1.

Adequate clinical muscle relaxation was subsequently maintained with intermittent vecuronium, although the relaxant was not given when T1% exceeded 25 (Table 1). Vecuronium was administered when the patient breathed out-of-phase with the ventilator. The isoflurane concentration was not changed at any time during the procedure. The total duration of surgery was one hour and 50

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Table 1. Relationship between time, block and incremental doses of vecuronium.

Time since bolus injection (minutes)	T1%/T%	Incremental dose (mg)
7	25/20	0
12	35/10	2
28	50/10	2
45	45/10	2
57	25/10	2
67	35/10	2
83	25/0	2
97	40/10	2

minutes. Atropine 1.2 mg and neostigmine 2.5 mg were given at the end of surgery and the neuromuscular functions returned to normal. The rest of the postoperative period was uneventful and the patient was discharged after 9 days.

Resistance to the non-depolarising relaxants, including vecuronium, in patients on chronic phenytoin therapy was reported by Ornstein *et al.*¹ who showed that a large dose of vecuronium was required in phenytoin-treated patients in order to provide a given level of neuromuscular blockade. When vecuronium 0.1 mg/kg was given, maximum block (100% depression of twitch height) occurred in 4.3 (SD 0.7) minutes and 25% recovery took 19 (SD 4) minutes. The onset of block in our case was exceptionally delayed with the higher loading dose of vecuronium, and produced only a maximum of 75% block of twitch height after 7 minutes. The duration of clinical relaxation was also short and variable. Incremental doses of vecuronium were not given at 25% recovery of the

twitch height because of a suspected fault in the recording system, the variable time of 25% recovery; the surgical procedure enabled us to wait for the clinical recovery. Close examination of the recordings of the relaxograph proved the recording to be correct because the clinical recovery and 25% recovery of the twitch height were not very much different.

It is concluded that resistance to vecuronium in patients who receive chronic phenytoin therapy is not merely an academic problem. Much larger and more frequent doses may be required in clinical settings.

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A benefit of clinical trials

A recent Seminar in 9, Bedford Square on the subject of Clinical Trials in Intensive Care emphasised the benefits of performing studies on critically ill patients. One of the advantages was that procedures or techniques which were introduced as part of a clinical trial later became standard practice to the benefit of all patients who enter that unit.

An example of this phenomenon is the development of a

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function of a pupillometer. The first version was made simply by drilling holes of known diameter through strips of clear flexible perspex. Nurses found these early devices useful, so a second version was produced by a local firm; in this the opportunity exists for adding other useful information such as an ECG ruler. The scale on the bottom of Figure 1 is simply copied from the observation

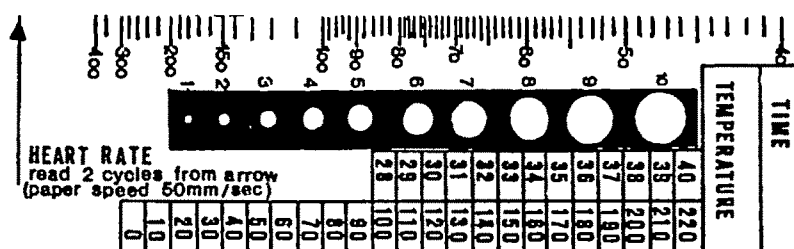


Fig. 1. A simple pupillometer.

simple pupillometer which was necessary for a trial of sedation in head injured patients. Pupillometers are described but they were not available in this unit and nurses estimated the size of patients' pupils and then drew a circle of approximately the same size on the observation chart.

We have made a nurse's ruler which incorporates the

chart and makes it easier for the nurse to record pulse and blood pressure at the correct point on the chart.

This, therefore, is an example of a beneficial 'spin-off' which may occur when clinical trials are undertaken.

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Intratracheal muscle relaxants—a possible route

Intratracheal administration of two muscle relaxants, pancuronium and alcuronium, was investigated since this route might be used in extreme circumstances when venous access is impossible. Suitable approval by a local ethics committee was obtained.

Anaesthesia was induced with diazepam and tracheal intubation achieved in two groups of 20 patients, ASA 1-2, for elective upper abdominal surgery.

Tracheal intubation was facilitated by 1.5 mg/kg suxamethonium, preceded in one group by 0.03 mg/kg pancuronium and in the other by 0.07 mg/kg alcuronium. Pancuronium (0.1 mg/kg) and alcuronium (0.2 mg/kg) each combined with 80 mg lignocaine were sprayed into the trachea before insertion of the tracheal tube. Anaesthesia was maintained with halothane in 50% nitrous oxide and oxygen.

Supplementary relaxants were given intravenously after the start of surgery at the request of the surgeon or in case of a normal response to tetanic or train-of-four stimulus.

The tracheal instillation-to-effect interval was 10-15 minutes after alcuronium and 15-20 minutes after

pancuronium. Eight patients required pancuronium 1 mg and five pancuronium 2 mg before the start of surgery; four patients required alcuronium 10 mg. Twelve patients required no further pancuronium during 1-2 hours of surgery, but two required pancuronium 1 mg after one hour, and six required pancuronium 1-2 mg after 2 hours. Eight patients required no further alcuronium during operations which lasted an hour; eight others required 5 mg after between 40 and 50 minutes of surgery, and four required between 5 and 10 mg alcuronium in operations which lasted more than an hour.

We conclude that both drugs are effective by the intratracheal route but there is a delay of between 10 and 15 minutes before they are effective. The effects of these drugs seem to be similar after administration by this route as after intravenous administration.

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Subarachnoid spread or injection?

Unusually high sensory blockade after attempted extradural administration of local anaesthetic may result from misplacement of an extradural catheter.^{1,2} A high block may also be possible with a correctly placed catheter

in the presence of local anatomical problems.³ Determination of catheter position using radio-opaque contrast medium, after an extensive block has occurred, adds to our knowledge of the potential problems associated with

extradural anaesthesia. However the report by Drs Leach and Smith (*Anaesthesia* 1988; 43: 671-4) requires clarification.

The authors do not specify the type of extradural catheter used. A triple side-hole catheter as is commonly employed may have one orifice in the subarachnoid space and another in the extradural space. Variable amounts of local anaesthetic solution may then be deposited in the subarachnoid as opposed to the extradural space depending on the force of injection.⁴ If a catheter with more than one orifice was used, their case report cannot be regarded as confirmation of the hypothesis that local anaesthetic spread occurred from the extradural space to the subarachnoid space through a dural puncture. Three separate confirmed dural punctures at two levels would make it not unlikely that a fourth dural puncture had taken place with subsequent misplacement of the catheter.

I also question the wisdom of approaching the extradural space above the level of termination of the spinal cord after multiple failed attempts at extradural catheter insertion, two of which resulted in dural puncture at the L₁₋₂ interspace.

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hemicranial palsy after a 'test dose' for extradural analgesia. *Anesthesiology* 1975; 43: 370-2.

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A reply

Thank you for the opportunity to reply to Dr A. Lee.

A Portex three side-hole catheter was used in this case. We certainly considered the possibility that the catheter tip had passed through a hole in the dura, but believed this unlikely for two reasons. Cerebrospinal fluid could not be aspirated and no deviation of the catheter tip was seen on X ray screening.

Dural puncture can occur unexpectedly during any attempted epidural (lumbar or thoracic). T₁₂L₁ is not a level we would normally use for obstetric epidurals, but a final attempt was made at this level in order to insert a catheter both for analgesia and as a means of prevention of spinal headache.

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Pyrexia and epidural blood patch

Drs Barker, Haxby and Robinson (*Anaesthesia* 1988; 43: 606) reported the management of a patient who had developed a postdural puncture headache and a fluctuating pyrexia immediately postpartum. A successful epidural blood patch was performed 5 days later when the patient had become afebrile.

The authors questioned whether the presence of a pyrexia had justified delaying the blood patch, thus denying the patient the benefits of headache relief until the pyrexia had resolved.

Evidence linking epidural abscess formation and epidural vein puncture in the pyrexial patient is sparse. Baker *et al.*¹ reviewed 39 cases of epidural abscess over a 27-year period and only one was associated with insertion of an epidural catheter. A review by Verner *et al.*² revealed an incidence of 0.2-1-2/10 000 hospital admissions. There has been no significant increase in the incidence of epidural abscess despite the increased use of epidural analgesia and anaesthesia in recent years.

There is no firm relationship between the parturient's temperature and the possibility of bacteraemia³ since only 9.7% of febrile patients are bacteraemic. Bacteraemia may occur after simple bladder catheterisation (8% if the urine is sterile)⁴ increasing if the urine is infected⁵ and may also occur after normal vaginal delivery.

In spite of the extremely low incidence of epidural abscess related to the insertion of epidural catheters or injection of blood into the epidural space in the presence

of pyrexia, the management of the case described, was, in my view quite correct. Treating the postdural puncture headache conservatively for 5 days is by no means too long since some obstetric anaesthetists consider that the appropriate timing of a blood patch is 3-6 days after dural puncture.

In the days of defensive medicine, one would have to think of a good reason to justify the injection of potentially infected blood into the epidural space.

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Does labetalol affect neuromuscular recovery?

A 68-year-old 65-kg female required anaesthesia for cataract surgery. She was a known hypertensive and required atenolol 50 mg daily for the control of her blood pressure. Blood pressure before operation was 180/95 mmHg. She was premedicated with lorazepam 2 mg and atenolol 50 mg 2 hours before the operation. Anaesthesia

was induced with fentanyl 75 µg and propofol 125 mg. Tracheal intubation was facilitated with 6 mg vecuronium. Her lungs were ventilated and anaesthesia was maintained with 33% oxygen, 66% nitrous oxide and 1% isoflurane. Blood pressure, heart rate and end-tidal carbon dioxide were monitored. The total duration of surgery was 35

minutes and neuromuscular blockade was reversed with glycopyrronium 0.5 mg and neostigmine 2.5 mg. She was wide awake, breathing adequately and was transferred to the recovery ward where blood pressure and oxygen saturation were monitored. Systolic blood pressure was greater than 200 mmHg and diastolic blood pressure above 110 mmHg for five consecutive readings 10 minutes later. We decided to treat the hypertension with labetalol and three divided doses to a total of 75 mg were given without much effect. The oxygen saturation started to decrease and she became cyanosed after a further 5 minutes. Blood pressure was still elevated and heart rate was 85/minute with sinus rhythm. Consciousness was now impaired. Breathing was found to be inadequate but there was no element of bronchospasm or respiratory obstruction. Her lungs were manually ventilated with 100% oxygen for a few minutes but her breathing did not improve and she required assisted ventilation. She was again given glycopyrronium 0.25 mg and neostigmine 1.25 mg. Her breathing returned to normal and oxygen saturation improved to 95% without oxygen supplement. She was given papaveretum 15 mg for sedation and blood pressure returned towards pre-operative values after a few minutes. The remainder of the postoperative period was uneventful.

Ocular manifestation of propofol allergy

Propofol is claimed to cause a very low incidence of allergic reactions,¹ but there are some reports of erythema, nonspecific rashes, phlebitis, peri-orbital oedema² weals³ and itchy rash⁴ after propofol injection. This is a report of a case in which signs of an allergic reaction to propofol were seen in the eyes and with transitory skin rashes.

A 42-year-old female with a history of asthma and hay fever presented as a day case for dilatation and curettage. There was no history of previous general anaesthesia. She occasionally used a salbutamol inhaler. A 20-gauge cannula (Venflon) was sited in a vein in the dorsum of her left hand and propofol 125 µg, injected slowly. The patient complained of slight pain at the injection site before she lost consciousness, but no abnormality was noted on examination. Anaesthesia was continued with nitrous oxide, oxygen and enflurane. No other intravenous drugs were given. A weal and flare reaction appeared on the dorsum of the hand and forearm over the next 2–3 minutes. Blood pressure was slightly lower than before induction. The patient breathed spontaneously until the end of surgery through a Bain system. She did not develop any breathing problems.

The patient complained after recovery from anaesthesia of an itchy sensation in the hand at the injection site. She complained of sore eyes within a few minutes of regaining consciousness. Examination revealed severe bilateral conjunctival chemosis. A generalised pruritic maculopapular rash appeared over the next few hours. She was treated with a single dose of intramuscular hydrocortisone 100 mg, chlorpheniramine maleate 4 mg three times a day orally and betamethasone ointment, hourly to both eyes. The rash and conjunctival chemosis had almost disappeared within 48 hours. The patient, however, continued to

Beta-adrenergic drugs are known to accelerate acetylcholine synthesis, possibly by activation of cyclic AMP, but do not affect the release process.¹ Furthermore, betablockers were shown to aggravate myasthenia gravis; animal experiments and a few case reports indicate prolongation of the action of tubocurarine, but the evidence of interaction is inconclusive.² In the described case labetalol which has both alpha and beta blocking properties appeared to be the cause of postoperative inadequate breathing, perhaps by an effect on acetylcholine synthesis or release; this is further suggested by the return of neuromuscular function after the administration of the reversal agents. It will be interesting to know if other anaesthetists have similar experience.

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complain of itching and soreness of the eyes for over 3 months and the topical steroid therapy was continued in reduced dosage. The lower tarsal conjunctivae in both eyes showed a persistent papillary reaction. She was symptom-free and ocular examination was normal when the patient was reviewed 15 weeks after her operation.

She had had no previous adverse reactions to other drugs despite the history of atopy. The timing of the rash and ocular signs strongly implicate propofol as the most likely cause of this unusual allergic reaction.

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Propofol and dreaming

Propofol is a popularly used induction agent for day care anaesthesia. The majority of day care patients are admitted to undergo minor gynaecological surgical procedures. A study of 50 day-care women who had minor gynaecological surgery showed an incidence of 24% patients who, on recovery from propofol nitrous oxide, oxygen, and enflurane anaesthesia reported dreaming during general

anaesthesia. All the patients studied were ASA grade 1 and had no premedication. Three of the 12 patients who dreamt during anaesthesia woke up in the recovery area surprised to realise that they were in hospital. They revealed on awakening that they had been dreaming and thought they were at home. The other nine patients only revealed their experiences on close questioning in the

ward on the postoperative visit by the anaesthetist. The dreams were all related to their family life and were all pleasant experiences. No patient had any complaints of the dreams they had and were not affected by them.

The patients' sense of well-being was good in all those who dreamt during anaesthesia, and they were all discharged from the ward 4–6 hours after surgery.

Dreaming during propofol anaesthesia is described by numerous authors^{1–6} in several studies. The dreams are always described as pleasant, and this is not considered to be an undesirable side effect of propofol. However one patient is described by de Grood *et al.*⁷ who experienced bad dreams during propofol, alfentanil and suxamethonium anaesthesia.

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Kinking of a Seldinger wire

The use of triple-lumen central venous catheters is increasing since the advantages of a single catheter which allows simultaneous multiple infusions and central venous pressure monitoring are recognised. Anaesthetists are familiar with most complications of central venous cannulation.¹ We report a complication related to the Seldinger technique using a triple-lumen catheter.

A 72-year-old man was about to undergo replacement of a regurgitant prosthetic mitral valve; his right internal jugular vein had therefore been cannulated previously. A guide wire with 'J' tip was inserted through the supplied 17-g needle (Multicath, Vygon, France) after easy identification of the right internal jugular vein. Resistance was encountered after approximately 13 cm of wire had been inserted and therefore both the 10-cm needle and wire were removed together. Inspection of the wire 1 cm distal to the needle tip demonstrated severe kinking; the wire was almost broken in two (Fig. 1).

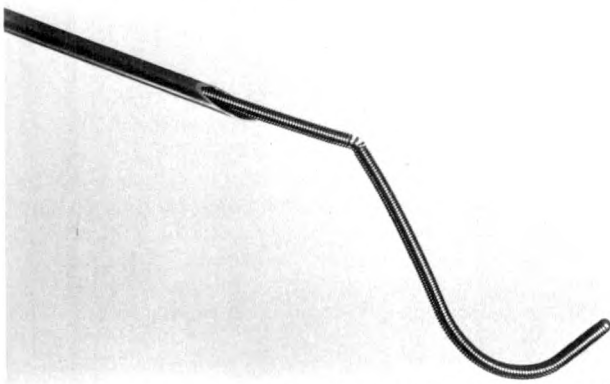


Fig. 1. The Seldinger wire with marked kinking distal to the needle tip found on removal of the wire and introducing needle.

Kinking of the guide wire is not uncommon, but we have never seen this degree of deformity and the manufacturers have no record of a similar occurrence. Subsequent to this episode, two further wires were noted to be kinked before insertion into the vein. The batch of these catheters has subsequently been withdrawn for investigation and quality control.

It is clearly important therefore to inspect the guidewire during insertion to avoid use of damaged wires. This report also emphasises the need for careful technique in central venous cannulation, particularly if abnormal anatomy may be present after previous cannulation. The guide wire should never be withdrawn through the needle since this may result in the danger of embolisation of a distal fragment.

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A reply

Thank you for the opportunity to comment on this unusual report. There was a temporary change in the way in which guide wires were positioned inside the packs of Multicaths. The change allowed the guide wires to move 2–3 cm within the pack. This movement created the possibility of damage to the guide wire during transit.

The change in packaging method was very brief, and affected only a very small number of catheters. No other damaged wires were found on examining the stock at Southampton, and no other reports were received concerning this batch of 440 catheters. Our investigation found a further two damaged guide wires in a second batch of 90 catheters. The packaging reverted to the previous presentation and no further problems were reported.

We endorse the comment concerning the need to observe the correct procedures when using Seldinger technique, and we stress the most unusual nature of this reported experience.

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R. BROOKS

Patient-controlled analgesia: the need for caution

Patient-controlled analgesia (PCA) provides good analgesia for most patients. However, just like any other piece of equipment, all PCA systems are governed by Murphy's Law.¹

Drs Thomas and Owen (*Anaesthesia* 1988; 43: 770-2) catalogue a list of potential problems. We have experience of the use of PCA on about 600 patients and have examined the problems of introducing PCA into an ordinary District General Hospital. We too have encountered some problems but set against these must be put the problems of conventional intramuscular analgesia. How many patients become obtunded from too large a dose of intramuscular opiate and subsequently develop bronchopneumonia? How often does naloxone have to be used in the hospital? How many patients lie still because of severe pain only to develop deep vein thrombosis? How many are unable to comply with the chest physiotherapy because of pain? Any problems with PCA or other analgesic technique have to be examined against this background. Theoretically PCA is very safe and the American experience supports this.² Large groups of patients need to be studied to confirm this and to establish the true morbidity of the technique. One wonders whether if intramuscular analgesia were to be introduced today it would be accepted as a safe, effective technique!

Unfortunately Drs Thomas and Owen do not mention one important safeguard against the potential problems of PCA. This is the nurse. Nurses relieved of the drudgery of administering repeated intramuscular analgesics have more than adequate time to monitor the patient and the equipment. This is perfectly feasible on any ordinary surgical ward in a District General Hospital. We have insisted on a simple monitoring programme which seems to alert staff to inadequate or excessive analgesia as well as other problems. If the nurse is able to monitor a patient for hypovolaemia then he (she) is able to monitor PCA. If not, then perhaps major surgery should be suspended.

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A reply

Thank you for the opportunity to reply to Dr Notcutt's letter. We agree, as enthusiastic advocates of PCA that there are many problems with conventional intramuscular analgesia. The purpose of our paper was to report a complication which occurred with one of the newer PCA machines and to take the opportunity to summarise previous reports where respiratory depression has been a problem with this method of pain relief.

The case report comments on the satisfactory use of the PCA apparatus for a 24-hour period. Unfortunately the broken syringe and positioning of the machine led to a large overdose of morphine to the patient. Despite these problems the vigilance of the ward nursing staff led to successful treatment. This event highlights the need for well trained and experienced nursing staff, but it is perhaps worth elaborating on this point. How frequently should breathing be monitored by a nurse on a busy ward? Even if the respiratory rate were to be counted every 30 minutes it would still be a discontinuous method of monitoring. This may make the case for the continuous monitoring of respiratory function using pulse oximetry.

It is important that further development of PCA occurs with appreciation of potential complications. Adherence to established PCA guidelines, together with improved methods of continuous monitoring of respiratory depression, must surely lead to more extensive use of such an effective method of pain relief.

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H. OWEN

Pulse oximeters and finger nails

Two healthy young women were noticed during general anaesthesia, to have low oxyhaemoglobin saturations when a Radiometer 'OXI' pulse oximeter with finger probe was in use. The measured saturation was in both cases about 84%. The probe appeared to be correctly positioned, as indicated by a good pulse signal, so a cause for the hypoxia was immediately sought. Clinically they were well oxygenated and no cause for the indicated desaturation was found. The probe itself was inspected and found to be apparently well placed in both cases. However, when the probe was removed from their fingers, both were found to have a long finger nail which protruded beyond the end of the finger pulp. When the probe was repositioned on the same fingers the saturation readings remained low, but when replaced on other fingers without such long nails, the readings rose to 97-

99%. These were more in tune with the clinical observations.

Presumably the long nail prevents correct seating of the probe over the finger tip, such that the finger pulp does not completely cover the light path between the light emitting diode and the light detector; but this is not immediately obvious because the equipment still indicates that an adequate pulse signal is detected. A similar observation was made when the probe was used on the relatively short finger of a child. Thus a very long finger nail may be another cause for a falsely low oxygen saturation, as detected using a pulse oximeter with a finger probe.

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A possible hazard

The majority of complications of central venous cannulation are well recognised but this incident has not previously been noted. A right internal jugular line was

fully withdrawn just prior to the ligation of the superior vena cava during surgery for the removal of the heart and lungs from a donor patient. However, withdrawal of a

Drum-cartridge catheter, inserted through the right cephalic vein was overlooked, and on division of the superior vena cava the distal 1 cm of this catheter was seen to have been cut through and to lie in the lumen of the lower portion of the superior vena cava. Fortunately it was held firmly in place by the ligature around the vein, and was easily removed with forceps. It is not inconceivable, however, for it to have fallen into the right atrium and gone

unrecognised, until embolic complications occurred in the recipient of the transplant.

Before the start of surgery for removal of the heart or heart and lungs *all* catheters should be withdrawn from the vena cava and their positions confirmed radiographically.

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P.A. ISAAC

'Ethics' of difficult intubation

Our main purpose in reporting our experience was to highlight the unusual dilemma of ethics posed by the patient. For this reason the anaesthetic technique was not described in detail. Fibreoptic endoscopy was in fact used at first, *pace* Dr Shankar (*Anaesthesia* 1989; **44**: 176) but the patient's extremely unfavourable anatomy and our limited experience with the technique resulted in failure to intubate. Tracheal intubation was eventually achieved by guiding a tube over a bougie which was passed blindly.

The fibreoptic technique in experienced hands would doubtless shorten the intubation time, but even a matter of minutes may be too long a delay when emergency

anaesthesia is required for severe haemorrhage or fetal distress. Obstetric complications are not restricted to office hours and it is highly unlikely that the specialised anaesthetic skills required would be immediately available, 24 hours a day. The only way to guarantee rapid, reliable tracheal intubation for this patient must therefore remain elective tracheostomy under local anaesthesia at 34 weeks' gestation.

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C.C. CALLANDER

Book reviews

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Monitoring cerebral function: long-term monitoring of EEG and evoked potentials, 2nd edn.

P.F. PRIOR AND D.E. MAYNARD. Pp. 466. Elsevier, 1988. £91.33.

Twenty years ago anaesthesiologists and other medical professionals involved in the care of critically ill patients faced the problem of the absence of electroencephalographic (EEG) monitoring devices; there now seems to be almost a plethora. Several appear to the user as black boxes which produce coloured maps. Today's problem is to understand what the black box is doing and what clinical conclusions can be drawn. There was thus a strong demand for this book. It is based on the old-fashioned cerebral function monitor (CFM), and its newer development, the CFAM. Nevertheless the first four chapters cover virtually all theoretical and technical aspects of EEG recording and processing which have to be considered when dealing with automatic EEG analysis and which apply to every EEG monitor on the market. This section of the book gives valid and basic information about, not only the common terms (analog filtering, spectral analysis, Fast Fourier Transform, power spectral density) but also about the more advanced, and not so well known EEG processing methods of period analysis, Kalman filtering, adaptive segmentation or pattern recognition.

These chapters are masterpieces of condensation and translation: the relevant aspects of modern signal and spectrum analysis and their specific application to the electroencephalogram occupy 140 very readable pages. This part of the book, in conjunction with an excellent index, also serves as a kind of dictionary of EEG analysis and the quoted references allow one to explore details elsewhere.

The EEG may be a little old-fashioned but the fact that it still exists means that it has stood the test of time and that it may be very useful to the clinician. What is the value of a monitor which undergoes regular changes in software such that yesterday's recordings are completely different from tomorrow's? Thus Prior and Maynard then present, and illustrate by a plethora of convincing examples, in the remainder of the book (440 pages) many applications, and a considerable amount of data about applied EEG monitoring, which they have collected over more than a decade. The topics range through physiological and pathophysiological factors which influence the EEG, EEG monitoring in anaesthesia, during cardiac and vascular surgery, on the intensive care unit and in neurology and neurosurgery, as well as fetal and neonatal monitoring and research applications. Each topic is

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covered by a self-contained and well referenced chapter.

The authors are right to state that the CFM and CFAM are of value as trend monitors in a number of fields of research, but I would hesitate to use it as a research tool on its own. This is, however, not its handicap but its advantage; because it is designed as a simple robust monitor of cerebral electrical activity for routine use, as stated by the late Professor D.G. McDowall in the foreword to the first edition.

This book is recommended to every clinician involved in the care of critically ill patients who seeks a method to assess brain function. Moreover, the book seems to me an excellent introduction and compendium of EEG monitoring for those scientists who are going to apply EEG trend monitoring in research.

The numbers of bytes of information related to the number of pages and the price of the book is not only fair, but good.

H. SCHWILDEN

Anaesthesia and the aged patient

Edited by H.T. DAVENPORT. Pp. xiii + 328. Blackwell Scientific, 1988. £42.50.

Dr Davenport has done a service to his fellow anaesthetists by gathering together in this volume a series of valuable contributions both from within and without the discipline of anaesthesia. He has been fortunate to persuade authors to write on the subject from their own particular viewpoint and the result is a fascinating book, a mine of information on a wide variety of subjects, presented with balance and common sense.

There is something to interest the reader on almost every page. Dr Halsey considers the basic science of ageing. His chapter and the succeeding one by Dr Warnes from the Age Institute of Gerontology at King's College provide much information not generally available in the anaesthetic literature. The different body systems are then considered in turn by Dr Cripps (cardiovascular), Professor Gareth Jones (respiratory) and Dr Hildick-Smith (nervous system). As one might expect the first two are erudite contributions from anaesthetists, but Dr Hildick-Smith, a consultant in geriatric medicine, offers a wide ranging physician's view, including the neurochemistry of ageing and disease, cerebral blood flow, stroke, confusional states, dementia and autonomic disorders. Dr Twining, a psychologist, writes on such topics as memory, emotions, personality, normal and abnormal ageing, the assessment of mental function and implications for anaesthetic practice. Professor Hall writes on patterns of disease in the aged and

Professor Tucker on the mechanisms of altered drug effects, an essential chapter for anaesthetists. Professor Lye writes on another important topic, electrolyte balance.

Decision making is often a multi-disciplinary process in the aged. Mr Vowles considers surgical aspects, while Dr Davenport himself writes on preparation for anaesthesia. Dr Dodson continues on how general anaesthesia might require modification and Dr Wildsmith discusses the place of regional techniques. Dr Seymour and Dr Vaz, two physicians, consider postoperative complications, while Dr Hopkinson looks at the role of intensive care for the aged.

Dr Evans writes on chronic pain in the aged, a difficult but important subject. He considers aspects of general management and goes on to highlight special subjects such as postherpetic neuralgia, other neuralgias, degenerative joint disease and cancer pain. Finally, Dr Denham, a consultant in geriatric medicine, sums up current views on the ethics of treatment and research.

Each chapter is well written, offers a considerable quantity of information, and is supplemented by a carefully chosen list of references and suggestions for further reading, mostly from sources readily available to the clinical anaesthetist. The print is easy to read, the tables clear, the index adequate. Dr Davenport is to be congratulated on producing a volume with a good balance between theory and practice, and with a good mix of contributors from the specialties as well as between academic departments and busy general hospitals. Every clinical anaesthetist has to consider the needs of an ageing population and this book is thoroughly recommended to this end.

R.S. ATKINSON

Anaesthesia and co-existing disease, 2nd edn.

R.K. STOELTING, S.F. DIERDORF AND R.L. MCCAMMON. Pp. ix + 936. Churchill Livingstone, 1988. £50.00.

The authors of this book state that their aim is to produce an introduction and reference source for the pathophysiology of diseases and their treatments relevant to the peri-operative period. This, then, is a textbook of medicine seen from an anaesthetic perspective, and its 936 pages are economical considering the size of the subject.

The 36 chapters are ordered by system, disease or specific population. One hundred and eighty-six pages are devoted to the cardiovascular system, 64 to respiratory disease, 91 to neurology. No major subjects are omitted; psychiatry, pregnancy, paediatrics and geriatrics have their own chapters; and in this second edition space is given to aspects of organ transplantation and AIDS. Somewhat surprisingly, the book starts abruptly without an introduction. There are no general comments on pre-operative assessment, the value of routine pre-operative investigations, the influence of anaesthesia on outcome, or the risk stratification of patients: the reader is left to scour individual chapters since none of these subjects appears in the index. The reason for this is perhaps the American belief that to understand pathophysiology is to be a good physician.

The editor-authors say that new material has been incorporated to within 6 months of publication. It is therefore disappointing to find no mention of studies such as the Confidential Enquiry into Peri-operative Deaths which incorporate information on the influence of coexisting disease and outcome. Opiates in patients with renal failure is given a reference dated 1975, with no reference to studies published in 1970 and since 1985 on morphine glucuronides; on the same subject, prostaglandins are mentioned in the text but not indexed, and there is no

reference to the adverse effect of analgesic prostaglandin inhibitors on marginal renal function.

Monitoring for patients with coronary artery disease is limited to three pages, and consists of a discussion of the ECG, flotation catheters and echocardiography; methods of measuring arterial pressure are not included. Regional blocks are given one paragraph, but there is no discussion of the stress response. The authors suggest that glycopyrronium offers few advantages over atropine in its chronotropic effects without describing rate of administration in patients with cardiac disease, and in the section on myasthenia gravis no specific advice is given on the peri-operative administration of anticholinesterases or the reversal of muscle relaxants.

The prophylaxis of renal failure, in which the anaesthetist plays a cardinal role, is discussed satisfactorily, but the section on septic shock is weak; there are only six references for the management of this syndrome with an average mortality of 50%, and the reader could be directed to many useful reviews.

The illustrations are well presented and apposite, and do not employ chart-junk.

However, it is easy to criticise a book of such a wide scope, and most of the subjects are very well presented. It is not a textbook which seeks to tell one how to give an anaesthetic; it is intended to increase one's knowledge of basic disease mechanisms and how these may be affected by anaesthesia. It is then left to the reader to use an appropriate anaesthetic technique in the light of that knowledge. To this extent it succeeds, and appropriately used will help the profession to reduce the morbidity and mortality associated with the peri-operative period. I recommend it strongly to all anaesthetic departments, and it should be included in the reading list of examination candidates. The price is not unreasonable, and interested individuals, particularly consultants who require to bring their knowledge outside their own field of anaesthesia up-to-date, will not be disappointed if they buy their own copy.

J.F. BION

Current practice in anaesthesiology

Edited by M.C. ROGERS. Pp. xiii + 328. Blackwell Scientific, 1988. £36.50.

All the 104 contributors to this book with the exception of a single Irishman work in the United States. This is an average of almost exactly three pages per contributor. One might anticipate this to be a fault, but in fact the format of short, snappy chapters (the longest is seven pages) makes for an interesting, informative and readable book.

The declared intention is to give recognised experts in their field the opportunity to describe 'how they do it'. This proves to be a successful formula for all but a few. The intended audience within the United States is obviously residents and fellows, and it is likely that this book will appeal to both new senior house officers in our specialty and registrars revising for their Fellowship exam.

Each chapter is short, and does not attempt a comprehensive review of the subject. There are no references as such, although most of the chapters have a list of four or six sources for further reading. The index is reasonably comprehensive, although hardly necessary since the list of chapter titles at the front give a good enough idea of where to look for a given subject. There are only a few basic illustrations, but many good, informative Tables. The book attempts to cover the whole subject of anaesthesia; it starts with pre-operative evaluation, then deals with anaesthesia for a wide variety of surgical procedures, and finally considers pain management (acute

and chronic) and postoperative intensive care.

Most of the chapters are well written, and recommend simple clinical evaluation before 'high tech' intervention. If it were not for the transatlantic spelling, this book could easily have been written by British authors. Most of the techniques advocated in this book are entirely applicable on this side of the Atlantic. The 'crystalloid versus colloid' argument gets ample airing (most favour the former), and an excellent case is made for one type of monitoring that is little used in Britain, the precordial or oesophageal stethoscope.

Some chapters are worth specific mention. All those on pre-operative considerations are cogent and full of common sense. The chapter on fractured hip in the elderly patient gives a good review of spinal versus general anaesthesia, and decides the most important factor is a highly skilled anaesthetist and surgeon. The chapter on spinal anaesthesia has a good section that discusses the aetiology and management of hypotension, and the chapter on techniques and monitoring contains a good, brief review of the indications for and complications of pulmonary artery catheters. Finally, the most interesting, informative and well researched chapter in the book is that on oxygen toxicity: this certainly will change my practice considerably.

It is inevitable in a book like this that there is some repetition and some downright bad chapters. Are four chapters on obstetric anaesthesia necessary, when all four consider similar points? Similarly there is repetition in the chapters on cardiac anaesthesia, especially in those for valve disease. One chapter that confused me is on central nervous system trauma in children. Written in a rather unnatural and stilted style, the author, after describing routine management, discusses 'extraordinary therapy'. He states that he uses high dose barbiturates in some situations but then goes on to say that they do not have any effect. Maybe I am missing something!

This book is not a substitute for the commonly used text books of anaesthesia. However it is excellent for quick reference, problem cases, and exam revision. Every anaesthetic department should purchase a copy.

I.S. GAUNTLETT

Year book of critical care medicine 1988

Edited by M.C. ROGERS, M.D. ALLO, J.M. DEAN, R.W. MCPHERSON, J.R. MICHAEL, C.F. MILLER, R.J. TRAYSTMAN AND R.C. WETZEL. Pp. 466. Year Book, 1988. £34.

This is the sixth annual edition of *Year Book of Critical Care Medicine* and it includes journals reviewed up until July 1987. There are eight editors who all work at Johns Hopkins University School of Medicine. Articles have been selected by the editors from 94 medical journals, which are mainly from the USA although a handful of foreign journals are represented, including *BMJ* and *Lancet*. The book consists of abstracts from cited scientific papers each of the order of 200–400 words long, most of which are followed individually or in small groups by critical comment by one of the Year Book editors.

The content of the book is arranged into 15 chapters according to subjects which range from cerebral haemodynamics to socioeconomic and ethical issues. Papers reviewed include retrospective and prospective surveys, clinical trials on laboratory experiments. Often, two or three papers on similar subjects are reviewed together. Apart from the predominance of papers from North American journals, the authors' choice of papers is reasonably catholic. The chapters vary somewhat in the type of paper reviewed; the first chapter on Emergent (*sic*)

Care and Trauma contains a large number of papers which review methods of practice, whereas in later chapters there is a great number of papers reporting clinical research.

In general, however, there is a great variety of subject matter, much of which is currently controversial, and the book is a valuable source of varied viewpoints on such issues. The editors appear to have made a conscious effort to include an interesting mixture of the important, the contentious, the unusual and sometimes the light-hearted. One editor even owns up after a particular abstract to the fact that 'this is a fascinating report with little or no relevance to critical care medicine'!

The critical commentary by the editors of the Year Book varies between praise and damnation, and between verbosity and complete absence. This latter fact is rather surprising in some instances and involves distinctly debatable abstracts. In some cases parts of the original papers, which are not reproduced in the Year Book, are discussed which is a little disorientating.

There are many graphs and tables, and a few photographs and drawings. These are on the whole quite clear, although some illustrations are not accompanied by a full explanation of abbreviations. There are two indices, author and subject, and these are comprehensive and clear.

So to whom would this book appeal? Intensivists will find the entire contents of interest, but other anaesthetists will also find various parts worthwhile. It is a book which fulfils two roles; the index allows one to seek out specific topics, but the book can also be used as a 'browser' to fill a few spare moments. Certainly, all Intensive Care Units and Anaesthetic Departments would benefit from owning a copy of this book.

N.D. GROVES

Obstetric anaesthesia

S. RAMANATHAN. Pp. 420. Quest-Meriden, 1988. £30.94.

The obstetric anaesthetist requires up-to-date general medical knowledge as well as obstetric anaesthetic skills. Pregnancy is achieved, and a successful outcome expected, in an increasing number of patients with serious concomitant and intercurrent medical disorders. This book attempts to fill a gap in the currently available obstetric anaesthetic literature.

It is divided into three sections. The first on normal pregnancy contains excellent chapters on the respiratory functions of the placenta, perinatal pharmacology and local anaesthetics. Each chapter is illustrated by succinct diagrams that enable the reader to assimilate easily basic physiology and pharmacology.

Throughout the book the author has made maximum use of diagrams, frequently culling the best from other authors' papers (always acknowledged) to illustrate various points. This reviewer expects that many of the diagrams will be used in tutorials for all grades of staff.

The disappointment afforded by the chapters on analgesia for labour and anaesthesia for Caesarean section is rapidly assuaged by the second section on high risk pregnancy. The author has set himself a mammoth task and executed it admirably. He has succinctly summarised the literature (always giving reference) and produced a balanced view on conditions such as hypertension, endocrine disorders, neurological disorders, anaesthesia in nonobstetric situations and drug abuse. It is this section to which the practising obstetric anaesthetist will refer continually.

The third section on the neonate contains an informative chapter on assessment of fetal well being which is mandatory in any modern obstetric anaesthetic textbook.

Our neonatal colleagues care in the United Kingdom for the premature infant with neonatal emergencies, but these chapters refresh the obstetric anaesthetist's memory and are more relevant with the prevalence of antenatal diagnosis and successful surgery for many congenital conditions.

The title of the book is a little inappropriate since *Obstetric anaesthesia* implies principles and practice. This book is not for the novice obstetric anaesthetist but for the practitioner who has mastered basic techniques and background knowledge. It is a necessary purchase for the bookshelf in the anaesthetic office of every busy maternity unit, especially those providing regional and supra regional services.

R. MACDONALD

A History of Longworth Scientific Instrument Co. Ltd.

SIR ANTHONY JEPHCOTT. Pp. 204. Regency Press, 1988. £9.50.

This little book recounts the history of one firm, well known to all British anaesthetists, which for its first 30 years struggled from humble beginnings to become one of the foremost manufacturers in the anaesthetics instrument industry.

First under the brand name of 'Longworth' and now of 'Penlon', its products are renowned throughout the anaesthetic world for their high quality, and reliability, and for the way they supply the anaesthetist's needs exactly. The firm has been a model of cooperation with clinicians. Anyone with an idea for an instrument or a gadget will receive a sympathetic and helpful hearing if he takes his idea to Longworths because they know only too well that new anaesthetic products can only come from ideas and needs born in the operating theatre and wards. Indeed the greater part of the success of this firm has been due to the help given them by numerous anaesthetists over the years,

and in particular by Macintosh and his associates at Oxford.

The book is well written by Sir Anthony Jephcott, Longworth's Managing Director and driving force for 20 years. It is an interesting book to read, although for most anaesthetists a little overburdened with archive data and manuscript reproductions, so beloved of academic historians.

Hardly a book for the average anaesthetist, it does merit a place in the archives of our new College or of the Association of Anaesthetists. Since it is cheap enough and essentially celebratory of the well deserved success of Longworths, presentation copies will not come amiss to their original anaesthetic friends of 40 years ago, of whom, sadly, so few still remain. To them, the names of Jephcott, Suffolk, Ripley, Sugg, and others of the firm, will recall good friends, as well as skilled and helpful instrument makers and business men.

W.W. MUSHIN

Books received

We thank the publishers for the following books, some of which will be reviewed in future issues of the journal.

Accidental hypothermia and near drowning

Edited by R.C.G. GALLANDAT HUET, Th. S.M. EUVERMAN, N.R. COAD, R. DE VOS AND C.F. KARLICZEK. Pp. x + 122. Van Gorcum, 1988. Dfl. 65.

Evoked potentials – intra-operative and ICU monitoring

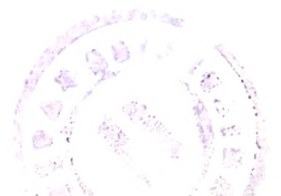
Edited by B.L. GRUNDY AND R.M. VILLANI. Pp. 200. Springer-Verlag, 1988. DM 86.

Care of the critically ill, 3rd edn.

S.M. AYRES, R. SCHLICHTIG AND M.J. STERLING. Pp. 425. Year Book Medical, 1988. £59.50.

Imaging and labelling techniques in the critically ill

Edited by W. KOX, J. BOULTBEE AND R. DONALDSON. Pp. xv + 188. Springer-Verlag, 1988. £93.



Anaesthetic literature

This section of *Anaesthetic literature* contains references taken from *Current Contents—Life Sciences* for November 1988. The Journals which may be consulted when *Anaesthetic literature* is compiled are those listed in *Current Contents—Life Sciences*, published by the Institute of Scientific Information, Philadelphia, Pennsylvania, USA.

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The collator of this section is Dr L. Kaufman, MD, FFARCS, Anaesthetic Office, The Rayne Institute, University College, University Street, London WC1E 6JJ. Dr Kaufman is prepared to provide on request, and at a modest charge, a new additional service to our readers. References from January 1984 have been entered on data base. The data are held on Dbase II, cpm 86 and on Dbase III, MsDos and are available on disc, together with a program providing search facilities. Enquiries direct to Dr Kaufman at the above address please.

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- Pathology of the central nervous system in 40 cases of acquired immune deficiency syndrome (AIDS). GRAY F, GHERARDI R *et al.* *Behaviour* 1988; **106** (Parts 3–4): 365.
- Turnover of brain histamine and its change by various drugs. OISHI R. *Folia Pharmacologica Japonica* 1988; **92**: 271.
- Intracranial arterial blood flow velocity and brain blood flow during hypocarbica and hypercarbia in newborn lambs—a validation of range-gated Doppler ultrasound flow velocimetry. SONESSON S-E, HERIN P. *Pediatric Research* 1988; **24**: 423.

Treatment and medication

- Calcium channel blockers correct acidosis in ischemic rat brain without altering cerebral blood flow. BERGER L, HAKIM AM. *Stroke* 1988; **19**: 1257.
- Muscle strength, endurance and recovery in the post-infection fatigue syndrome. LLOYD AR, PHALES J, GANDEVIA SC. *Journal of Neurology, Neurosurgery and Psychiatry* 1988; **51**: 1316.
- Controversies in the management of cerebral vascular disease. SCHEINBERG P. *Neurology* 1988; **38**: 1609.
- Leukocyte response in patients suffering from acute stroke. VIOLI F, RASURA M *et al.* *Stroke* 1988; **19**: 1283.

Endocrine and metabolic

Physiology

- Review: Adrenergic mechanisms in the control of corticotrophin secretion. AL-DAMLUNI S. *Journal of Endocrinology* 1988; **119**: 5.
- Transcutaneous oxygen pressure measurements in type 1 diabetic patients for early detection of functional diabetic microangiopathy. BREWER HWM, BREWER J, BERGER M. *European Journal of Clinical Investigation* 1988; **18**: 454.

- Intravenous vasopressin infusion decreases plasma ACTH concentration in conscious dogs. BROOKS VL, BLAKEMORE LJ, KEIL LC. *American Journal of Physiology* 1988; **255** (No. 4 Part 2): R665.
- Low-dose dopamine infusion, renal haemodynamics and urinary albumin excretion rate in insulin-dependent diabetics and in normal man. CHRISTIANSEN JS, PEDERSEN MM *et al.* *Scandinavian Journal of Clinical and Laboratory Investigation* 1988; **48**: 679.
- Thyroid function testing: a new era. GORMAN CA. *Mayo Clinic Proceedings* 1988; **63**: 1026.
- Characterization of human platelet vasopressin receptor and the relation between AVP-induced platelet aggregation and AVP binding to platelets. INABA K, UMEDA Y *et al.* *Clinical Endocrinology* 1988; **29**: 377.
- Effects of vasopressin on atrial natriuretic peptide release and renal function in dogs. INOUE M, KIMURA T *et al.* *American Journal of Physiology* 1988; **255** (No. 4 Part 1): E449.
- The insulin receptor and the molecular mechanism of insulin action. KAHN CR, WHITE MF. *Journal of Clinical Investigation* 1988; **82**: 1151.
- Effects of calcium on renin and aldosterone. KOTCHEN TA, GUTHRIE GP JR. *American Journal of Cardiology* 1988; **62**: 41G.
- On the pathogenesis of insulin-dependent diabetes mellitus. MANDRUP-POULSEN T. *Danish Medical Bulletin* 1988; **35**: 438.
- Thyrotropin radioimmunoassays: birth, life, and demise. RIDGWAY EC. *Mayo Clinic Proceedings* 1988; **63**: 1028.
- Pathogenesis of sodium and water retention in high-output and low-output cardiac failure, nephrotic syndrome, cirrhosis, and pregnancy (second of 2 parts). SCHRIER RW. *New England Journal of Medicine* 1988; **319**: 1127.
- Effect of alpha-2-andrenoceptor antagonist on platelet activation during insulin-induced hypoglycaemia in type 2 diabetes mellitus. TAKEDA H, KISHIKAWA H *et al.* *Diabetologia* 1988; **31**: 657.
- Use of sensitive immunoradiometric assay for thyrotropin in clinical practice. TOFT AD. *Mayo Clinic Proceedings* 1988; **63**: 1035.

Treatment and medication

- Immune and metabolic effects of arginine in the surgical patient. DALY JM, REYNOLDS J *et al.* *Annals of Surgery* 1988; **208**: 512.
- Corticosteroid replacement therapy; twice or thrice daily? GROVES RW, TOMS GC *et al.* *Journal of the Royal Society of Medicine* 1988; **81**: 514.
- Assessment of perioperative risk in the patient with diabetes mellitus. MACKENZIE CR, CHARLSON ME. *Surgery—Gynecology and Obstetrics* 1988; **167**: 293.
- Assessment of insulin action in man—role of hyperglycemia. MARTENS E, ZICK R *et al.* *Acta Endocrinologica* 1988; **119**: 213.
- Incidence of severe hypoglycemia and its causes in insulin-treated diabetics. NILSSON A, TIDEHOLM B *et al.* *Acta Medica Scandinavica* 1988; **224**: 257.
- Screening for diabetes mellitus. SINGER DE, SAMET JH *et al.* *Annals of Internal Medicine* 1988; **109**: 639.
- Oral administration of magnesium hydroxide on insulin-dependent diabetes mellitus: effects on magnesium and potassium levels and on insulin requirements. SJOGREN A, FLOREN C-H, NILSSON A. *Magnesium* 1988; **7**: 117.
- Effect of metoclopramide on dopamine-induced changes in renal function in healthy controls and in patients with renal disease. SMIT AJ, MEUER S *et al.* *Clinical Science* 1988; **75**: 421.
- Subcutaneous or nonsubcutaneous injection of insulin. SPRAUL M, CHANTELAU E *et al.* *Diabetes Care* 1988; **11**: 733.
- Effects of an oral water load and IV administration of isotonic glucose, hypertonic saline, mannitol and furosemide on the release of ANP in men. YAMASAKI Y, NISHIUCHI T *et al.* *Acta Endocrinologica* 1988; **119**: 269.

Pain

Physiology

- The spinal route of analgesia for acute and chronic pain. COUSINS MJ. In: DUBNER R *et al.*, eds. *Proceedings of the Vth World Congress of Pain*. Amsterdam: Elsevier, 1988: 454.
- Analgesic effect of epidural clonidine. GERMAIN H, NERON A, LOMSSY A. In: DUBNER R *et al.*, eds. *Proceedings of the Vth World Congress of Pain*. Amsterdam: Elsevier, 1988: 472.

- Comparison of the analgesic efficacy of metamizole and tramadol in experimental pain. ROHDEWALD P, GRANITZKI HW, NEDDERMANN E. *Pharmacology* 1988; **37**: 209.
- Minireview: Substance P antagonists and analgesia: a review of the hypothesis, VAUGHT JL. *Life Sciences* 1988; **43**: 1419.
- Stability and instability of central pain mechanisms. WALL PD. In: DUBNER R *et al.*, eds. *Proceedings of the Vth World Congress of Pain*. Amsterdam: Elsevier, 1988: 13.
- Peripheral release of substance-P from primary afferents. YAKSH TL, BAILEY J *et al.* In: DUBNER R *et al.*, eds. *Proceedings of the Vth World Congress of Pain*. Amsterdam: Elsevier, 1988: 51.
- Properties of the modulation of spinal nociceptive transmission by receptor-selector agents. YAKSH TL, STEVENS CW. In: DUBNER R *et al.*, eds. *Proceedings of the Vth World Congress of Pain*. Amsterdam: Elsevier, 1988: 417.

Treatment and medication

- An evaluation of different doses of soluble aspirin and aspirin tablets in postoperative dental pain. HOLLAND IS, SEYMOUR RA *et al.* *British Journal of Clinical Pharmacology* 1988; **26**: 463.

- Continuous intercostal nerve block for pain relief after thoracotomy. SABANATHAN S, BICKFORD SMITH PJ *et al.* *Annals of Thoracic Surgery* 1988; **46**: 425.
- The effect of buprenorphine on the analgesic and respiratory depressant effects of pethidine: a preliminary study. VEDIG AE, GIBBS JM *et al.* *Pain* 1988; **34**: 253.

Other

Treatment and medication

- Propranolol or endoscopic sclerotherapy in the prevention of recurrence of variceal bleeding—a prospective, randomized controlled trial. ALEXANDRINO PT, ALVES MM, CORREIA JP. *Journal of Hepatology* 1988; **7**: 175.
- Transplantation of the liver in adults and children with fulminant hepatic failure. VICKERS C, NEUBERGER J *et al.* *Journal of Hepatology* 1988; **7**: 143.

Safety Action Bulletin

The Safety Action Bulletin has replaced the Safety Information Bulletin of the Department of Health

Anaesthetic vaporizers: servicing (88)72

An incident is reported in which a gas leak was caused by the failure of the locking mechanism at the anaesthetic machine/vaporizer interface; this was attributed to the lack of servicing of the vaporizer.

Graseby patient-controlled analgesic system (PCAS) syringe driver: modification of pneumatic switch system (88)74

The Department has received a report of an incident in which a Graseby patient-controlled analgesia system (PCAS) syringe driver delivered a bolus of drug without demand by the patient.

Hewlett Packard battery pack (PT No. 1420-0339) used in HP defibrillators type 43100A, 43110A, 43120A, 4313A and 43200A (88)75

Battery packs fitted to certain Hewlett Packard defibrillators of the above mentioned types may not meet the published capacity specification, even when fully charged. The manufacturer's estimate of battery life is reduced.

IMED 800 syringe pump: replacement of syringe select knob (88)76

The Department has received a report of the select syringe knob on an Imed 800 digital syringe pump which gives an incorrect indication of the setting and does not correspond to the legend on the panel; mis-setting becomes likely.

Courses in Anaesthesia

The information below is believed to be accurate but those intending to attend a course should check the details with the relevant organiser. Applications and further information cannot be provided by *Anaesthesia*.

FCAnaes Part 1

LONDON St Thomas' Hospital, London SE1 7EH	Day release Fridays 17 March-2 June	£150	Department of Anaesthetics, St Thomas' Hospital, London SE1 7EH
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FCAnaes Part 2

LONDON St Thomas' Hospital, London SE1 7EH	Day release Thursdays 23 February-27 April	£150	Department of Anaesthetics, St Thomas' Hospital, London SE1 7EH
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Association of Anaesthetists of Great Britain and Ireland

Annual Report of Council 1987–1988

1. Membership of the Association (as at 30.7.88)

The total Membership of the Association 5483 (5474).

Honorary	73	(73)*
Ordinary	2093	(2090)
Junior	1961	(1931)
Corresponding	32	(34)
Overseas	909	(928)
Retired	432	(386)
Senior	11	(13)
Associate	12	(14)

* This figure now includes deceased Honorary members.
(Last year's figures in brackets).

There were 91 resignations during the year.

Deaths

Council records with regret the death of the following members:

Al-Azawi, S.A. (*Welwyn, Herts*). Bannatyne, B. (*Scotland*). Bereen, J.F. (*Belfast*). Burkinshaw, E. (*Sheffield*). Challenger, J. (*Denmark*). Cousineau, E. (*Montreal*). Crawford, J.S. (*Birmingham*). Farman, J. V. (*Cambridge*). Farrar, M.D. (no address). Flowerdew, F.D. (*Dorset*). Forrest T. (*Liverpool*). France, J.M. (*Scarborough*). Galley, A.H. (*Middlesex*). Goodhart, C.E.D. (*Carshalton*). Hewitt, A.J. (*Ireland*). Hurdmann, F.K. (*Shrewsbury*). Jones, O.M.E. (*Oxford*). Jordan-Sikorksa, Z.A. (*London*). Middleton-Price, J. (*Wirral*). Oliver, F.W. (*Halifax*). Parry, J.W.L. (*Aberdeen*). De Saram, B. (*Canterbury*). Taylor, J.C. (*Aberdeen*). Thomas, R. (*Dyfed*). Thompson, A. (*London*). Tun, H. (*Rangoon*). Willis, E.A. (*London*). Wilson, K.M. (*London*). Young, J.V.I. (*Kent*).

2. John Snow Silver Medal

Council recommended the award of the John Snow Silver Medal to:
Dr W.D. Wylie.

3. Honorary Membership

Council recommended for election to Honorary Membership:
Dr Aileen K. Adams, CBE; Professor J.W. Dundee; Lord Smith of Marlow, KBE.

4. Pask Certificate of Honour

Council made the award of Pask Certificate to:
M. Freeman Esq. Chairman of BAREMA; Dr J.E. Fairfield, Research Registrar, Guy's Hospital, London.

5. Sir Ivan Magill Gold Medal for Innovation in Anaesthesia

This medal was awarded for the first time in 1988 to Dr J.F. Nunn, PhD, MD, FRCS, FFARCS, FFARCS(I)Hon, FFARCS (Hon).

6. Annual Scientific Meeting 1987

The Annual Scientific Meeting was held at the Octagon Centre, University of Sheffield on Thursday and Friday 10–11 September 1987. A scientific and social programme of a very high standard had been organised by Dr J.R. Cole, Professor W.S. Nimmo, Dr A. Padfield and their colleagues in Sheffield. There were over 380 registrants. The John Snow Lecture 'The University, Medical Research and the NHS' was delivered by the Right Honourable Lord Dainton of Hallam Moors (*Chancellor of the University of Sheffield*).

The Annual Dinner was held at the Cutlers' Hall, Sheffield. Distinguished guests included Sir Michael Carlisle, Mr D. Bray, Master Cutler, and Sir Cecil Clothier.

7. Annual General Meeting 1987

The Annual General Meeting was held at the Octagon Centre, Sheffield, on Friday 11 September 1987. The President, Professor M. Rosen, was in the chair and over 170 members were present.

The award of the John Snow Silver Medal to Dr P.J. Helliwell, Past President of the Association, (introduced by Professor M.D. Vickers) was received with acclamation.

Honorary Membership was conferred on Sir Cecil M. Clothier KCB, QC (introduced by Dr W.R. MacRae), Professor K. Rawnsley (introduced by Dr M.M. Burrows) and Professor M.H. Holmdahl.

Professor Holmdahl was not able to be present at Sheffield and the presentation was made on Friday 15 January 1988 at the Winter Scientific Meeting.

Pask Certificates of Honour were awarded to L. Small Esq. Scientific and Technical Branch, DHSS, Dr Valerie Major (*Vellore, India*) and Dr P.R. Rayner (*Chesterfield*).

The Minutes of the Meeting have been circulated to Members.

8. Linkman Conference 1987

The twelfth Annual Conference of Linkmen was held at the Octagon Centre, Sheffield, on Wednesday, 9 September 1987. The President, Professor M. Rosen, was in the Chair and over 130 Linkmen attended. The subjects for discussion were supervision of patients in the operating theatre; minimal monitoring; anaesthetic services for smaller obstetric units; assistance for anaesthetists;

stress amongst trainees in anaesthesia; registrar bulge and some solutions; confidential enquiry into peri-operative deaths and survey of anaesthetic practice.

A detailed report of the conference has been circulated to Linkmen and published in the August 1988 issue of *Anaesthesia*.

9. Postgraduate Study Day 1987

This meeting, held jointly with the Faculty of Anaesthetists at the Royal College of Surgeons of England, London, on Saturday 17 October, 1987 was again very successful. The format of previous years was maintained thereby enabling registrants to attend six lectures of their choice from the total of 18 lectures delivered.

Despite a storm on the previous day which disrupted travelling arrangements 289 of 320 booked registrants had attended.

10. Winter Scientific Meeting

The first Winter Scientific Meeting of the Association, held on Friday and Saturday, 15–16 January 1988 at the Royal College of Surgeons of England, London, was highly successful. An excellent scientific programme had been prepared by Professor G. Smith; there were over 400 registrants.

A Certificate of Honorary Membership of the Association was presented to Professor M.H. Holmdahl (introduced by Professor J.P. Payne) on Friday 15 January 1988.

An associated dinner was held at the Waldorf Hotel, Aldwych, London on Friday 15 January 1988. Distinguished guests included Sir John Walton, Sir Christopher Booth and His Excellency the Venezuelan Ambassador.

11. Annual Scientific Meeting for Junior Anaesthetists 1988

This meeting, held at the East Midlands Conference Centre, University of Nottingham, on 6–8 April 1988 was again very successful. The meeting was very well organised by Dr G. Flowerdew, Dr P.J. Matthews and Dr P. Tomlinson and was attended by 200 anaesthetists in training.

The scientific programme included specific sessions devoted to the adult respiratory distress syndrome, aspects of perinatal physiology, modern teaching techniques, new radiological techniques, anaesthesia and the EEG and hypertension.

The Pinkerton lecture entitled 'Basic Science and Anaesthesia' was delivered by Dr M.J. Halsey, Head of High Pressure Neurological Syndrome Group, Division of Anaesthesia, Clinical Research Centre of the Medical Research Council, Harrow, Middlesex.

The prize and President's medal for the Junior Anaesthetists' Annual Prize Competition was awarded to Dr M.S. McKinnery (*Craigavon, Northern Ireland*).

12. Association Sponsored Meetings

(i) A Tribute to Sir Robert Macintosh on his 90th Birthday

This successful meeting sponsored by the Section of Anaesthetics of the Royal Society of Medicine, the Association of Anaesthetists and the Faculty of Anaesthetists was held on Friday 2 October at the Royal Society of Medicine, London. A souvenir volume containing the proceedings of the meeting has been published and may be obtained from the Royal Society of Medicine, price £7.95.

(ii) Sir Ivan Magill Centenary Meeting

This highly successful meeting organised jointly by the Section of Anaesthetics of the Royal Society of Medicine, the Association of Anaesthetists and the Faculty of Anaesthetists, to commemorate the birth of Sir Ivan Magill, KCVO, was held on Friday and Saturday 22–23 July 1988 at the Royal College of Surgeons of England. There were some 200 registrants.

The first award of the new Association honour, the Sir Ivan Magill Gold Medal for innovation in anaesthesia was presented to Dr J.F. Nunn by the President, Professor M. Rosen, at the Commemorative Dinner, held at the Royal College of Surgeons of England, on Friday 22 July 1988.

13. Future meetings

Association meetings

1988—Postgraduate Study Day, 15 October 1988, Royal College of Surgeons of England, London, organised jointly with the Faculty of Anaesthetists.

1989—Winter Scientific Meeting and Technical Meeting, 13–14 January 1989, Royal College of Surgeons of England, London.

—Junior Anaesthetists' Group Linkman Conference and Annual Scientific Meeting, 5–7 April 1989, University of Keele.

—Joint Meeting with the Canadian Anaesthetists' Society, 9–13 June 1989, Ottawa.

—Refresher Course and Scientific Meeting of European Academy sponsored by the Association of Anaesthetists and the European Section of the WFSA, 13–15 July 1989.

—Linkman Conference, 13 September 1989, Swansea.

—Annual Scientific Meeting and Technical Exhibition, 14–15 September 1989, Swansea.

1990—Linkman Conference, 26 September 1990, Manchester.

—Annual Scientific Meeting and Technical Exhibition, 27–28 September 1990, Manchester.

1991—Linkman and Annual Scientific Meeting, September 1991 (date to be announced), Cambridge.

1992—Linkman and Annual Scientific Meeting, September 1992 (date to be announced), Liverpool.

1993—Joint Meeting with the Canadian Anaesthetists' Society, 15–17 September 1993, Edinburgh.

Faculty and Royal College of Surgeons of England Meetings

1988—Symposium 'Safety and Standards in Anaesthesia', 3–4 November 1988, The Royal College of Surgeons of England, London.

1989—Anniversary Forum 'Day Case Anaesthesia', 15 March 1989, The Royal College of Surgeons of England, London.

—Symposium 'Anaesthesia, Intensive Care and the Liver', 5 May 1989, Birmingham.

—RCS Annual Meeting, 13 December 1989, The Royal College of Surgeons of England, London.

Other meetings

1988—7th Annual Meeting of the European Society of Regional Anaesthesia, 13–15 October 1988, Mainz, W. Germany.

1989—8th Annual Meeting of the European Society of Regional Anaesthesia, 17–19 May 1989, Lisbon, Portugal.

—5th World Congress on Intensive and Critical Care Medicine, 3–8 September 1989, Kyoto, Japan.

1990—VIIIth European Congress of Anaesthesiology (WFSA), 9–15 September 1990, Warsaw, Poland.

—8th Asian/Australian Congress of Anaesthesiologists (WFSA), 23–28 September 1990, Seoul, South Korea.

1992—3rd International Symposium on the History of Anaesthesia, 29 March–2 April 1992, Atlanta, Georgia.

—10th World Congress of Anaesthesiologists, 14–19 June 1992, The Hague.

14. Council

During the year October 1987–September 1988 Council met on four occasions and the Advisory Committee met on six occasions. The attendance of members at Council and the Advisory Committee is shown at the end of this report, together with the membership of the various subcommittees and working parties.

Council wishes to express its appreciation of the services of the permanent secretarial staff, Miss Ann Muir, Administrative Secretary and Mrs Betty Tyler, her assistant, Miss Pat Plant, Financial Secretary and her assistant, Miss Lyn Hunt, Mrs Catherine Goff, BOC Educational Coordinator and Dr Audrey Eccles, ICI Archivist/Librarian. During the year Miss Mary Atkinson, Minute Secretary, joined the administrative secretariat.

Council is extremely grateful to Mr E. Warburton, Financial Adviser, who, on an entirely voluntary basis, continues to give

outstanding support and advice to the Association on all aspects of its legal and financial affairs.

Retiring from Council this year will be Dr T.B. Boulton, Immediate Past President, who completes 23 years of continuous outstanding loyal service on Council in many offices including that of Editor of *Anaesthesia*. On completion of 2 years as Vice President Dr P.J.F. Baskett and Dr E.B. Lewis also retire from Council following many valued years of service to the Association; Dr Baskett as an elected member and Honorary Secretary, Dr Lewis as an elected and coopted member. Three elected members of Council retire after their 4-year term of office, namely, Professor A.P. Adams, Dr Elizabeth G. Bradshaw and Dr J.F. Searle, all of whom have contributed greatly to the work of the Association.

In commemoration of the life and work of Sir Ivan Magill, KCVO, who died in November 1986, in his 99th year, Council has commissioned a gold medal, the Sir Ivan Magill Gold Medal, to be awarded in recognition of outstanding innovations in the service of anaesthesia. The first award of this international honour has been made to John Francis Nunn, PhD, MD, FRCS, FFARCS, FFARCS(I)Hon, FFARCS(Hon), Head of the Division of Anaesthesia, Clinical Research Centre of the Medical Research Council, Harrow, Middlesex. The Association, in making this award, pay their tribute to an outstanding international medical scientist whose contributions have done much to promote and influence the science of anaesthesia during the last 40 years.

Dr J.S.M. Zorab, coopted member of Council, was elected President of the World Federation of Societies of Anesthesiologists at the General Assembly held in Washington DC in May 1988. This is only the second occasion on which a United Kingdom anaesthetist has held this high office.

Association Standing Committee, Republic of Ireland

The Standing Committee, Republic of Ireland of the Association of Anaesthetists of Great Britain and Ireland was established on 16 January 1988. The Committee consists of 13 members of the Association working in the Republic, and includes one elected from each of the eight Health Board Areas, one representing the Voluntary Hospitals, a representative of the Faculty of Anaesthetists of the Royal College of Surgeons in Ireland, a representative of the Faculty of Anaesthetists of the Royal College of Surgeons in Ireland and a representative of the Junior Anaesthetists' Group. The Convenor of the Committee is Dr D. Riordan, the Secretary Dr P.J. Breen and the Executive Officers of the Association are members ex-officio.

During its first 6 months, the Standing Committee has given active consideration to two important matters: Anaesthetic Services in the Republic and Professional Fees for Anaesthetists. Draft documents on these subjects were presented to a meeting of the Standing Committee held in Dublin on 25 June 1988.

Nine Bedford Square

The year has seen an extension of activities at 9 Bedford Square. The educational programme of seminars and workshops has been expanded and the House has been used by many anaesthetic and related societies and individuals for scientific, business and social meetings. The seminars have proved to be very popular with members. During the year 22 seminars were held covering a wide range of topics, some of which had been suggested by members. Council is extremely grateful to Dr J.F. Searle, seminar secretary, and the seminar organising committee, Professor G. Smith, Professor W.S. Nimmo and Dr J.A.W. Wildsmith, for organising the excellent programme.

The success of the programme was ensured, in no small part, by the efficient administrative skills of Mrs Catherine Goff, BOC educational coordinator. Council is most grateful to her for her enthusiasm and support. Mrs Goff left the administrative secretariat, for the happiest of reasons, in July 1988; her successor as BOC educational coordinator is Mrs Lesley Ogg.

15. Linkman Organisation

The Linkman organisation continues to be an important communication mechanism between Council and the membership. Council and Officers place a high value on the information and

opinions received from Linkmen both throughout the year and at the Annual Linkman Conference. To facilitate improved communication Council has designated an Officer, the incoming Assistant Honorary Treasurer, to act as Linkman coordinator. A review of the list of Linkmen has been undertaken and Linkmen are particularly requested to notify the Association office of any changes.

Linkmen were requested to provide information on:

- (a) Confusion arising from drug presentation.
- (b) Consultants nominated to be in charge of the anaesthetic service for obstetrics within individual districts.
- (c) Hospitals not represented in the Linkman scheme and satisfaction with existing arrangements.

Officers were encouraged by the very satisfactory response received to these enquiries.

Members and Linkmen are encouraged to make the Association aware of any matter of interest. The current list of Linkmen is given at the end of the report.

16. Education and Research Committee

Two meetings of the education and research committee (Chairman Professor W.S. Nimmo) were held during the year.

In addition to committee members and Officers, *ex officio*, the following attended by invitation: Dr P.J. Helliwell (chairman of working party on stress amongst trainees), Dr Rosemary Mason and Dr Patricia Steane (local organising committee for 1989 Annual Scientific Meeting, Swansea).

JAG Questionnaire for registrars

The results of this large survey, which was funded by the Association, were discussed at both meetings of the committee. A final report has been prepared by Dr Nancy Redfern and will be available in the near future. An advance copy has been made available to the Dean of the Faculty of Anaesthetists because of its relevance to the final examination of the FFARCS.

Scientific meetings

The committee reviewed draft programmes and recommended approval to Council of the Winter and the Annual Scientific Meetings for 1988 and 1989 as well as the JAG Annual Scientific Meetings.

Postgraduate Study Day

Professor W.S. Nimmo and Dr J.A.W. Wildsmith represented the committee on the working party to prepare the programme for the Postgraduate Study Day. This will be held on Saturday 15 October 1988.

Combined meeting with the Canadian Anaesthetists' June 1989

Dr P. Morris represented the committee and Council at the 1988 meeting of the Canadian Anaesthetists' Society held in June 1988, at Halifax, Nova Scotia, and a preliminary programme has been prepared.

Seminars and Workshops at 9 Bedford Square

These continue to be very popular. The programme is the responsibility of a small working party of the committee chaired by Dr J.F. Searle (Dr J.A.W. Wildsmith from 1988).

Adverse Drug Reactions

Professor W.S. Nimmo, Dr J.A.W. Wildsmith and Dr W.L.M. Baird represented the committee on the joint working party with the Faculty of Anaesthetists to improve reporting of adverse reactions in anaesthesia. A new yellow card for reporting anaesthetic reactions will be launched for a trial period of one year in September 1988. It is hoped that all anaesthetists will support this venture and increase the data base of anaesthetic adverse reactions.

BUPA funding of research in anaesthesia

The committee initiated and coordinated an approach to BUPA to fund research in anaesthesia. This was successful and research fellowships have been awarded to Leicester and Oxford for 2 years.

Association Research Fellowship

The Association Research Fellowship was held by Dr Angela Cooper (Cambridge) from 1986-88. The committee received satisfactory reports on progress. Dr Cooper gave a paper at Washington and Williamsburg, USA, in May 1988. The Association Research Fellowship for 1988-90 has been advertised and has attracted 14 applicants.

Research Grants

Council approved the following research awards recommended by the committee. Dr A.S.C. Rice (London) £4800 to study single nerve fibre transmission in rats and human volunteers. Dr I. Power (Edinburgh) £800 to study effect of drugs on peripheral nerve conduction. Dr P.J. Helliwell £5300 for a pilot study of stress amongst trainees. Two applications were not recommended to Council.

The policy of the committee is to obtain expert referees' reports on applications for research grants. The Association is grateful to these experts for their support throughout the year.

Travel grants

Two applications for travel grants were recommended to Council for approval: Dr C.S. Reilly (Sheffield) £340 and Dr R.S. Jones (Liverpool) £390.

Baxter Travelling Fellowship

In 1987 this was awarded to Dr D.J. Rowbotham (Sheffield) to enable him to pursue studies of patient-controlled analgesia in Europe and the United States of America.

Two applications have been received for 1988.

Undergraduate essay prize

The 1988 prizes were awarded as follows: 1st prize to M.H. Cooper (School of Medicine, University of Leeds) for 'Is a postoperative chest X ray of value after major abdominal surgery?' The 2nd prize went to J.A. Cooper (School of Medicine, Royal Free Hospital) for 'Malignant Hyperpyrexia'.

17. Safety Committee

The committee (Chairman Professor A.P. Adams) met on three occasions during the year.

At the request of Council two Working Parties have been set up to consider matters relating to (a) safe working monitoring (so-called minimal monitoring) and (b) checklists for anaesthetic machines. The first of these documents is complete and the other should be finalised early next year. Both these activities relate to increased concern for patient safety in the climate of increasing medicolegal premiums (consequent upon escalating damages awarded by the courts) together with similar concerns about safe standards of patient care by anaesthetists in the various developed countries of the world. Indeed, standards or recommendations for safe monitoring and checklists have already been produced in several countries; checklists are difficult because of the complexity, variability and interaction of different equipment used in the UK. It is hoped that these activities will support anaesthetists in their efforts to improve patient safety.

In the early 1960s there were many reports of accidental carbon dioxide overdosage to patients due to human error. The UK is one of only a very few countries where anaesthetists continue to request CO₂ on anaesthetic machines. The result has been a steady number of very tragic accidents with enormous legal costs. The Department of Health issues Safety Information Bulletins (SIBs)

at regular intervals and the Committee is aware that distribution is generally unsatisfactory, and it is particularly sad that an SIB warning about inadvertent CO₂ administration was published some months before the latest CO₂ tragedy in 1988. Council, on the recommendation of the Safety Committee, has issued a code of good practice relating to CO₂, namely: do not attach the CO₂ cylinder to the anaesthetic machine unless its use is intended for that particular case. The responsibility is clearly that of the anaesthetist and ODAs should be instructed always to remove any CO₂ cylinder from the yoke on discovering such a situation. A similar code of conduct should also relate to cyclopropane. Publicity on these matters has been directed to members through *Anaesthesia News*. The committee is currently having discussions with the British Anaesthetic and Respiratory Equipment Manufacturers' Association (BAREMA) with a view to introducing a flow limitation device on CO₂ flowmeters or, alternatively, a 5% CO₂ in oxygen yoke in place of that for CO₂ alone.

The committee is represented on the new DHSS Working Party on Antistatic Precautions for Anaesthetising Areas, and also on various other ongoing committees of various organisations.

Problems due to patient awareness and pulmonary barotrauma continue to occur as a result of the accidental 'locking-on' of the oxygen flush (emergency) control. The new Standard will require a nonlockable flush control unless the user requests otherwise. There is always a problem with older equipment since it is usually impossible, or highly expensive, for manufacturers to mount a retrofit program. However, firms belonging to BAREMA will arrange to remove the 'lock-on' O₂ flush facility upon request.

Members may have read a recent SIB (1988) which relates to an anaesthetic machine catching fire; this involved a quite old machine which had been declared obsolete by the manufacturers' servicing agents but replacement had not been carried out for reasons of cost. The moral is obvious.

The committee receives reports of the progress of British, European and International Standards from its representatives on the various committees and has the opportunity to discuss and put forward matters raised by members.

Much of the work of the committee is related to dealing with and answering the numerous questions and problems posed by anaesthetists. In this context the question of poor ampoule labelling has again been raised and the committee is pleased to report that helpful discussions have been held with a representative of the organisation responsible for DHSS pharmacy matters. Also, there are plans for a Standard of labelling based on adequate lettering against a background of colours relating to common agonists and antagonists. It is clear that poorly labelled ampoules relate to purchases made by hospitals at the lowest possible costs. Anaesthetists dissatisfied with ampoule labels should endeavour to bring pressure to bear on the purchasing authority.

The committee is also frequently asked by industry for its opinions on matters relating to the safety of equipment. Members of the committee have lectured on aspects of safety at various anaesthetic meetings.

18. International Relations Committee

This committee (Chairman Dr M.T. Inman) has met on two occasions and continues to review the requests received for help with the teaching of anaesthesia in developing countries. Help has been provided in Ghana, Tanzania, Sudan, Kenya, Nepal and Zambia. This help has been mainly in the form of post FFARCS registrars, and has varied from a 3-month lecturership, to a one-year contract which may be renewed.

Other countries, in Africa and the Pacific have asked for assistance and recruiting continues.

The committee continues to liaise with, and to respond to, the British Council, Overseas Development Administration, WFSA and others interested in these problems.

An exchange with the German Democratic Republic has taken place, and further exchanges are being explored.

19. Editorial Board

The Board met on three occasions, twice under the chairmanship of the President and once of Dr P.J. Helliwell who retired after 14 years' service to the Board in December, 1987. Dr J.N. Horton (Cardiff) was appointed as Assistant Editor to edit *Anaesthesia*

News, the Association's recent innovation. Dr M. Morgan (*Hammersmith*) was appointed Associate Editor in April, 1988. Dr J.A. Davies (*Lancaster*) succeeded Dr M.J. Harrison (*Nottingham*) (who emigrated) as collator of the index of computer programs. The decision to increase the page size of *Anaesthesia* was implemented in January, 1988 as part of the strategy to improve the facility to publish articles. *Anaesthesia News* also enabled this process while communication with members is maintained and will, it is hoped, in the future be improved. The National and Local Events Calendar therein is still prepared for the Association by Dr A. Padfield (*Sheffield*) and this contribution is gratefully acknowledged. Our publishers, Academic Press, received notice of our intention to renegotiate our contract with them in 1989.

20. Finance Committee

The Finance Committee (Chairman Professor M. Rosen) met twice during the year. The increase in Association activities generally and the expansion of the educational programme at 9 Bedford Square during the year had led to increased costs. These had been anticipated by the committee.

The committee reviewed subscription rates for 1989-90 and recommended that the full ordinary subscription from July 1989 should be £80 per annum, with increases, *pro rata* in other subscription rates.

The audited accounts have been circulated to members.

21. Private Practice Committee

The Private Practice Committee (Chairman Dr M.T. Inman) has met on two occasions. The guidelines document 'Fees for anaesthetists in private practice' was updated and published in January 1988. In addition the committee have also produced a document 'Guidance on the conduct of private anaesthetic practice'. This document emphasises the importance of the high standard and continuity of anaesthetic care necessary in the private sector.

Two seminars (one sponsored by BUPA) have been held at 9 Bedford Square, on the topic of Group Practice. These have explained the benefits and mechanisms of group practice.

Discussions with the Provident Associations have continued and changes in their traditional classification of operations have been discussed, along with many other topics.

22. Junior Anaesthetists' Group

The JAG committee has met four times in the past year. The chairmanship of the group passed from Dr G.W. Hamlin to Dr D.L. Paul following the Annual General Meeting held in April 1988 at Nottingham.

This year has seen six retirements from the JAG committee. On behalf of JAG, the committee would like to thank Dr G.W. Hamlin, Dr A.D.J. Nicholl, Dr G.J. Fitzpatrick, Dr K. Fitzpatrick, Dr P.A. Ritchie and Dr P.J. Matthews, retiring committee members, for all the work they have done on behalf of trainees during their tenure of office. Details of the current membership of JAG and a monthly newsletter will appear in *Anaesthesia News*. Fuller details can be found in the Linkman Newsletter sent out after each JAG meeting.

The Annual Scientific Meeting was held in Nottingham and over 200 trainees attended. The lecture facilities were superb and very convenient to the university accommodation. The scientific programme was good although we still have to find some way of attracting more entries for the Junior Anaesthetists' annual prize competition.

The Junior Linkman Scheme has just over 40 Linkmen. This is not enough to keep in touch with all trainees in the UK. JAG is reviewing the recruitment and duties of Linkmen to make the scheme more attractive and useful to trainees.

Following a pilot study several years ago, a working party on Stress in Trainees in anaesthesia has been set up. A five-year study is proposed to identify and quantify the causes of stress in trainees and to see if these change with time.

Members of the committee have fully represented JAG on committees and working parties of the Association, the Faculty of Anaesthetists and related bodies. JAG's full potential can only be realised if there is regular feedback from the trainees it represents.

23. Confidential Enquiry into Peri-operative Deaths

The Joint Committee (between this association and the Association of Surgeons of Great Britain and Ireland) under its chairman, Professor M.D. Vickers, was disbanded after the preparation of its report in December, 1987. Publication was achieved by the combined activities of the King's Fund and the Nuffield Provincial Hospitals' Trust. The Association acknowledges with gratitude both these charities for their generous support, over the 3 years, which enabled this enquiry to be undertaken. The Steering Committee for the National Confidential Enquiry into Peri-operative Deaths has representatives of all the surgical colleges; anaesthetists are represented by Professor M. Rosen for the Faculty of Anaesthetists and Drs M.M. Burrows and J.N. Lunn for the Association. This new committee is chaired by Professor D. Campbell (*Glasgow*) and the Enquiry is funded by the Welsh Office and the Department of Health. This group is independent of all other organisations.

24. The Anaesthetics Sub-committee of the CCHMS

The Anaesthetics Sub-committee (Chairman Dr J. Edmonds-Seal) has met twice in the past year. As well as advising individuals concerning terms and conditions of practice as anaesthetists, the Sub-committee has considered many matters of vital interest to the specialty. Some of these include 'Achieving a Balance', Personal Insurance for Flying Squad and Major Disaster Incidents, Associate Specialists on-call, NHS Dental Anaesthetic Fees, Study Leave for Clinical Assistants, and the Teaching of First Aid in Schools.

The subcommittee is aware of the lack of guidelines concerning the 'safety net' in anaesthesia and advises that it is vital for anaesthetists to become involved in the District and Regional Manpower Committees and the District Working Parties. The 'safety net' will vary from district to district and anaesthetists have an important role in advising all acute specialties on these matters. The initiative of previous years concerning insurance cover for call to Flying Squad and Major Disaster Incidents has borne fruit with publication of detailed advice in *Anaesthesia News* and *BMA News Review*.

Associate specialists are at present in negotiation about terms and conditions of employment. The subcommittee was asked to consider 'on-call' arrangements for associate specialists in anaesthesia, and concluded that given the wide range of experience and abilities of associate specialists and recognising that consultant cover was required at all times, associate specialists should not expect to be excluded from junior anaesthetist rotas in all circumstances. However, the subcommittee emphasised that associate specialists were senior hospital staff and that recognition must be given to this and to the effect of ageing when drawing up rotas. Normally, associate specialists would be on a senior anaesthetic rota provided that there was always a named consultant available.

The subcommittee recognised the problem of low fees for dental anaesthetics and has referred the matter to the Joint Negotiating Committee of the BMA, which has agreed to renegotiate with the DHSS and the BDA.

Concern has been expressed about study leave for clinical assistants in anaesthesia. As a result of discussion in the subcommittee, the matter is now receiving attention in the joint Negotiating Committee and the Faculty of Anaesthetists.

The subcommittee has supported the view that resuscitation and first aid should be taught in schools. Suitable motions have been accepted from the subcommittee to be debated at the conference of Academic Medical Organisations and the Annual Representatives Meeting of the BMA at Norwich this year.

The report of the Private Practice and Professional Fees Committee of the BMA on a new fees structure is still awaited, and will be dealt with as a matter of some urgency.

Further reports of the activities of the Anaesthetics Subcommittee of the CCHMS can be found in the minutes which are available.

25. Museum, Library and Archives Subcommittee

Dr T.B. Boulton is Honorary Archivist, Dr D.J. Wilkinson Honorary Curator of the Charles King Collection and Dr I.

McLellan Honorary Librarian. Dr Audrey Eccles continues her valuable work as ICI Archivist and Librarian.

The first of the planned annual exhibitions in the museum, on obstetric anaesthesia, opened on 9 July 1987 and was replaced in July 1988 by an exhibition in honour of the Magill centenary. Items from the Charles King Collection not on exhibition have now been moved to a rented outstore and work on repacking and documentation is progressing. Over 350 items donated by 27 individuals have been added to the collection in the last 18 months. Links have been established with the principal official museum bodies to ensure that care and documentation of the collection conform to professional standards.

The library has also received substantial donations. A number of historic books and films have been purchased, and the principal English language journals are taken and displayed in the library. Visitors to the museum and library are welcome at any time, but since many of the books are not housed in the library, members wishing to see a particular item or make specific enquiries are invited to contact Dr Eccles.

In addition to the Association's own archives, records from several other sources have been deposited, notably those of the Intensive Care Society.

Working Parties

Special Societies of Anaesthesia. A very useful exchange of information and ideas took place at the meeting between Officers and representatives of Specialist Societies held on Friday 26 November 1987. Representatives considered, unanimously, that the annual meeting was a good forum and agreed that Specialist societies who were willing to provide expenses for their representative would do so in the future. It was also agreed that the next meeting would be held on Friday 18 November 1988.

Joint Working Party with Obstetric Anaesthetists' on Anaesthetic Services for smaller obstetric units (Chairman Professor M. Rosen). The report of the Working Party 'Anaesthetic Services for Obstetrics—a plan for the future' was published in December 1987. The report has been sent to Linkmen, chairmen of health authorities and district general managers.

Considerable interest has been stimulated by the report and it has proved to be of value in assisting members to improve services locally. Additional copies of the report are available to members on application to the London office, price £1.50.

Working Party on Duties of Divisional Chairmen (Chairman Dr L.T. Rees). The working party has met on one occasion. A report has been drawn up to give guidance to chairmen of divisions of anaesthesia on the performance of their duties. The report will be sent to Linkmen and also made available to the membership in September 1988.

Joint Working Party with the Faculty of Anaesthetists on Services for Chronic Pain Relief (Chairman Dr J.E. Charlton). The working party has met on one occasion. A guidance document is being prepared. It is hoped that this document will be available for members by summer 1989.

Theatre Utilisation (Chairman Professor M. Rosen). The recent report of the Confidential Enquiry into Peri-operative Deaths and the National Audit Office publication entitled 'The Use of Operating Theatres in the National Health Service', have indicated that changes in the organisation of theatre services may improve the efficiency of operating theatre utilisation and lead to further improvement in standards of patient care. To respond to these reports in a positive fashion the Working Party has met three times, on one occasion with representatives from the Association of Surgeons and the British Orthopaedic Association.

The Working Party has considered whether the appointment of a theatre services manager and efficient data collection systems would improve theatre efficiency. Other aspects that have been discussed include emergency operating, tied theatre lists, infected cases, list publication, anaesthetic assessment, list cancellation and over-runs, and reasons for cancellation of lists and individual cases. Consideration has also been given to staffing and training needs, admission policies and the provision of adequate recovery facilities and support services.

It is hoped to hold a further meeting with members of the Association of Surgeons in the near future with a view to publishing a joint report, (and that the recommendations of the Working Party will be available to Council towards the end of the year). It is intended to offer oral evidence on behalf of the

Association to a DHSS Steering Group studying operating departments at present, and make the recommendations of the Working Party available to the membership early in 1989.

Minimal Monitoring (Chairman Professor A.P. Adams). A document 'Recommendations for Standards of Monitoring during Anaesthesia and Recovery' has been finalised and approved by Council. The document, to be published in September 1988, will be sent to Linkmen and made available to members on request, price £1.50.

Stress Amongst Trainees in Anaesthesia (Chairman Dr P.J. Helliwell). This working party was set up by Council as a result of representation from the Junior Anaesthetists' Group and because of information obtained from various surveys and enquiries made over the past few years. The working party includes representatives of Faculty of Anaesthetists' Tutors, nominated by the Dean of the Faculty.

The working party met on five occasions and has submitted a report to Council which includes various recommendations. These are based on the unique position of anaesthesia, as compared with other hospital specialties, in the organisation of its services, and giving regard to the highly technical and acute nature of the specialty.

The report strongly outlines the need for departments to lay down clear lines of communication and responsibility between trainers and trainees. It recommends the appointment of personal tutors who should be available to give advice and encouragement to trainees on all matters, clinical, social and career guidance. These will be complementary to the terms of reference for Faculty Tutors, laid down by the Faculty, and to the recommendations of the CEPOD report. The report will be discussed at the Linkman Conference in September 1988.

In the meantime, a survey is to be carried out, organised by Miss Jenny Firth-Cozens of Leicester University, designed to provide further information on various aspects of the problem. This survey will also serve as a baseline for a comparable study, to be undertaken in 5 years' time, which will indicate what success the present recommendations have had. Miss Firth-Cozens has already had considerable experience in assessing stress amongst junior doctors. It is hoped that all anaesthetists in training will cooperate in this investigation.

Assistance for Anaesthetists (Chairman Dr M.M. Burrows, President Elect). Council's continued commitment to the problem of assistance for anaesthetists is demonstrated by the setting up of this working party.

Consultation with a wide range of people and organisations involved with nurses and operating departments has revealed a measure of agreement on the nature of anaesthetists' needs and the substantial difficulties currently besetting services, although considerable geographical variations exist.

Initiatives from the DHSS (a new study of staffing and organisation of operating departments) and the National Health Service Training Authority (a project group on ODA training), suggest that change is in the air. The working party's recommendations favour evolution of a defined category of trained helper, anaesthetic department assistants (ADAs) and anaesthetic department nurses (ADNs) and seek to ensure fair rewards in terms of pay and career prospects for the staff on whom we so critically depend. In parallel with efforts for the future, advice and support for members during current difficulties has been prepared.

The working party gratefully acknowledges help from individuals and representatives of the following organisations: National Association of Theatre Nurses, British Association of Operating Department Assistants, National Association of Training Scheme Co-ordinators for Operating Department Assistants, National Association of Professional and Technical Theatre Personnel, United Kingdom Central Council for Nursing and Midwifery, National Health Service Training Authority, Association of Surgeons of Great Britain and Ireland, Department of Health and Social Security.

High Dependency Working Party (Chairman Dr J.F. Searle) and *Intensive Care Advisory Group* (Chairman Professor M. Rosen). These two groups were set up by Council in the autumn of 1986. Initially they worked separately. However, it became clear that there was a dearth of information about the provision of high dependency and intensive care services throughout the United Kingdom. Therefore, a questionnaire was agreed by the two groups and was sent to 290 general intensive care units. The

results of this survey were analysed during the autumn of 1987. It has formed the basis of an Association report, 'Intensive Care Services—provision for the future'. This will be published in September 1988. The report will be sent to Linkmen and made available to members, price £1.50.

One of the report's main recommendations is that intensive care services should be rationalised with only one general unit per health district. Critically ill patients in small hospitals should be stabilised in high dependency units and then transferred to a district or supradistrict intensive care unit. The report also recognises that in larger hospitals there are good economic as well as clinical reasons why high dependency beds should be in association with intensive care units.

It is clear that the present use of high dependency units is very diverse. Thus the working party is now identifying more sharply the role of such units. It expects to report in 1989 on the use, management, staffing and equipping of high dependency units. Consultations have already taken place with the Association of Surgeons of Great Britain and Ireland.

27. The Monospecialist Committee for Anaesthesia and Re-animation

The committee, (Association representative Dr W.R. MacRae, President Dr P.J.F. Baskett (Faculty of Anaesthetists' representative) has met on one occasion in September 1987 in Ghent, Belgium. The proposal that the minimum period of training in anaesthesia in EEC countries should be 5 years was approved by the UEMS.

Composition of Council, its Subcommittees and Working Parties

Council

Four meetings held (attendance in brackets).

Officers: Professor M. Rosen, President (4); Dr T.B. Boulton, Immediate Past President (3); Dr M.M. Burrows, President Elect/Honorary Treasurer (4); Dr R.S. Atkinson, Vice-President (4); Dr P.J.F. Baskett, Vice-President (4); Dr M.T. Inman, Vice-President (4); Dr E.B. Lewis, Vice-President (4); Dr W.R. MacRae, Assistant Honorary Treasurer (4); Dr P. Morris, Honorary Secretary (4); Dr W.L.M. Baird, Assistant Honorary Secretary (4); Dr J.N. Lunn, Editor (4).

Elected Members: Professor A.P. Adams (3); Dr D.S. Arthur (3); Dr Elizabeth G. Bradshaw (3); Dr K. Budd (3); Dr J.E. Charlton (4); Dr J. Edmonds-Seal (4); Dr Margaret L. Heath (3); Dr S.M. Lyons (4); Professor W.S. Nimmo (1); Dr J.F. Searle (4); Dr J.A.W. Wildsmith (4); Dr G.W. Hamlin, JAG (3) (until April 1988); Dr A.D.J. Nicholl, JAG (3) (until April 1988); Dr D.L. Paul, JAG (3) (since April 1988); Dr Jane Chestnut, JAG (1) (since April 1988).

Co-opted Members: Dr Aileen K. Adams; Dr P.W. Keane; Air Commodore C.A.B. McLaren; Professor Sir Gordon Robson; Professor M.K. Sykes; Professor M.D. Vickers; Dr W.D. Wylie; Dr J.S.M. Zorab.

Advisory Committee

Five meetings held (attendance in brackets).

Chairman: Professor M. Rosen (5); Dr M.M. Burrows (2); Dr W.R. MacRae (3); Dr D.S. Arthur (4); Dr P. Morris (5); Professor W.S. Nimmo (2); Dr J.N. Lunn (5); Dr W.L.M. Baird (5); Dr J.F. Searle (3); Dr G.W. Hamlin (3) (until April 1988); Dr D.L. Paul (2) (after April 1988).

Editorial board

Chairman: The President; *Editor:* Dr J.N. Lunn; *Assistant Editors:* Dr A.R. Aitkenhead, Dr P.J.F. Baskett, Dr R. Greenbaum, Dr J. Horton, Dr R.M. Jones, Dr M. Morgan, Dr C.F. Scurr. *Co-opted Members:* Mr E. Warburton (Financial Adviser), Mrs Joan Fujimoto (Academic Press), Miss Jane Lawrence (Academic Press), Miss Joy Clarke (Academic Press), Mr Ray Aller (Academic Press).

Education and Research Committee

Professor W.S. Nimmo (*Chairman*), Professor A.P. Adams, Dr R.S. Atkinson, Dr W.L.M. Baird, Dr Margaret L. Heath, Dr S.M. Lyons, Dr J.A.W. Wildsmith, Dr G.W. Hamlin, JAG (until April 1988), Dr D.L. Paul, JAG (after April 1988).

Safety Committee

Professor A.P. Adams (*Chairman*), Dr Elizabeth G. Bradshaw, Dr J. Charlton, Dr D.S. Arthur, Dr K. Budd, Air Commodore C.A.B. McLaren, Dr N.I. Newton, Professor M.K. Sykes, Dr P.W. Thompson, Dr Kate Allsop (MDU), Dr J. Hickey (Medical Protection Society), Dr R. Palmer (Medical Protection Society), Mr C. Bray (DHSS), Mr L.W.M. Arrowsmith (DHSS), Mr M. Freeman (*Chairman*, BAREMA), Dr P. Ritchie (JAG) (until April 1988), Dr P.J. Heath (JAG) (since April 1988).

International Relations

Dr M.T. Inman (*Chairman*), Dr W.L. Baird, Dr Elizabeth G. Bradshaw, Dr J. Bushman, Dr M. Dobson, Dr J. Edmonds-Seal, Dr J.A.W. Wildsmith, Dr P. Ritchie (JAG) (until April 1988), Dr G. Clarke (JAG) (since April 1988).

Representatives from:

Appropriate Health Resources and Technologies Action Group, British Council, Inter-varsity Council, Bureau for Overseas Medical Services, Overseas Development Administration, WFSA, Committee for International Cooperation in Higher Education.

Finance Committee

Professor M. Rosen (*Chairman*), Dr M.M. Burrows (*Honorary Treasurer*), Dr K. Budd, Dr J.E. Charlton, Dr E.B. Lewis, J.F. Searle, Mr E. Warburton (*Financial Adviser*).

Private Practice

Dr M.T. Inman (*Chairman*), Dr D.S. Arthur, Dr P.J.F. Baskett, Dr K. Budd, Dr J.E. Charlton, Dr E.B. Lewis.

Working Party on Anaesthetic Services for Smaller Obstetric Units

Professor M. Rosen (*Chairman*), Dr P. Morris (*Secretary*), Dr W.L.M. Baird, Dr Elizabeth G. Bradshaw, Air Commodore C.A.B. McLaren, Dr Nancy Redfern (JAG), Dr J. Thorburn, (OAA), Dr Rosemary MacDonald (OAA), Dr Barbara Morgan (OAA), Dr Wendy Scott.

Working Party on Assistance for Anaesthetists

Professor M. Rosen (*Chairman*), Dr Margaret L. Heath (*Secretary*), Dr D.S. Arthur, Dr J. Edmonds-Seal, Dr M.T. Inman, Dr S.M. Lyons, Professor M.D. Vickers.

Working Party on High Dependency Units

Dr J.F. Searle (*Chairman*), Air Commodore C.A.B. McLaren, Professor G. Smith, Dr J.A.W. Wildsmith.

Specialist Societies

President (*Chairman*).

Representatives from:

Age Anaesthesia Association, Association of Cardiothoracic Anaesthetists, Association of Dental Anaesthetists, Association of Paediatric Anaesthetists of Great Britain and Ireland, Faculty of Anaesthetists, RCS of England, History of Anaesthesia Society, Intractable Pain Society, Junior Anaesthetists' Group, Neurological Anaesthetists' Travelling Club, Obstetric Anaesthetists' Association, Plastic Surgery and Burns Anaesthesia.

Archives Working Party

Dr T.B. Boulton (*Honorary Archivist and Chairman*), Dr D.J. Wilkinson (*Honorary Curator*, Charles King Collection of Historical Apparatus), Dr I. McLellan (*Honorary Librarian*).

The Executive Officers of the Association are ex-officio Members of all Committees and Working Parties above.

Anaesthetics' Subcommittee of the CCHMS

Dr J. Edmonds-Seal (*Chairman*), Dr M.M. Burrows, Dr P. Morris, Dr Jane Chestnut (JAG).

Junior Anaesthetists' Group

Dr G.W. Hamlin (*Chairman*) (until April 1988), Dr D.L. Paul (after April 1988), Dr A.D.J. Nicholl (*Secretary*) (until April 1988), Dr Jane Chestnut (after April 1988), Dr P.J.F. Baskett (*Council representative*) (until April 1988), Dr P. Morris (after April 1988), Dr Anne Blythe (until April 1988), Dr G. Fitzpatrick (until April 1988), Dr P.J. Matthews (until April 1988), Dr P. Ritchie (until April 1988), Dr Maggie Smith (until April 1988), Dr G. Clarke, Dr D. Howes, Dr D. Laird, Dr A. Mackenzie, Dr J. O'Dea, Dr M. Platt, Dr A. Skidmore, Dr Elizabeth Spencer.

Honorary Adviser on Technical Exhibitions

Dr R.S. Vaughan.

UEMS Representative

Dr W.R. MacRae.

Faculty Advisory Panel on the Training of Anaesthetists (REAS)

Dr T.B. Boulton, G.W. Hamlin (JAG) (until April 1988), Dr D.L. Paul (JAG) (from April 1988).

National Resuscitation Standards

Dr P.J. Baskett.

Manpower Advisory Panel

Professor A.P. Adams, Dr G.W. Hamlin (JAG) (until April 1988), Dr Elizabeth Spencer (JAG) (from April 1988).

City of London Guilds (ODAs)

Dr M.T. Inman

Joint Committee for Higher Training of Anaesthetists

Dr P. Morris, Professor G. Smith (until October 1988), Professor W.S. Nimmo (from October 1988), Dr G.W. Hamlin (JAG) (until April 1988), Dr P.L. Heath (JAG) (from April 1988).

Trustees of the Anaesthetists' Academic Foundation

Dr H.C. Churchill-Davidson (until June 1988), P.J. Helliwell (until June 1988), Dr W.D. Wylie (until June 1988).

Working Party on Pre-anaesthetic Check Procedures

Professor A.P. Adams (*Chairman*), Dr P. Bickford-Smith, Dr J.D. Henville, Dr N.I. Newton.

Joint Working Party on Services for Chronic Pain Relief

Dr K. Budd (*Chairman*), Dr J.E. Charlton, Dr A.W. Diamond, Dr F.R. Ellis (Faculty of Anaesthetists, RCS of England), Dr P.J.D. Evans (Faculty of Anaesthetists, RCS of England), Dr D. Hatch.

Working Party on Minimal Monitoring

Professor A.P. Adams (*Chairman*), Dr J.E. Charlton, Professor M.K. Sykes.

Working Party on Theatre Utilisation

Professor M. Rosen (*Chairman*), Dr J.E. Charlton (*Secretary*), Dr Margaret L. Heath, Dr E.B. Lewis, Dr J.R.E. Jenkins, Dr A.F. Naylor, Dr A.M. Reid, Dr J.S.M. Zorab.

Intensive Care Advisory Group

Dr J.F. Searle (*Chairman*), Dr M. Branthwaite, Dr Doreen Browne, Dr M.T. Inman, Dr J.C. Stoddart, Dr M. Telfer, Dr J.A.W. Wildsmith.

Duties of Chairmen of Divisions of Anaesthesia

Dr L.T. Rees (*Chairman*), Dr P. Morris (*Secretary*), Dr D.S. Arthur, Dr J. Edmonds-Seal, Dr S.M. Lyons, Dr Anna-Maria Rollin, Dr D. Paul (JAG).

Working Party on Stress Amongst Trainees in Anaesthesia

Dr P.J. Helliwell (*Chairman*), Dr M.P. Coplans (*Secretary*), *Representatives of Council*: Dr P.J.F. Baskett (Council representative on JAG), Dr J. Edmonds-Seal, Dr M. Inman, Dr J.F. Searle, Professor G. Smith; *Representatives of Faculty Tutors, nominated by the Dean*: Dr Angela Mackersie, Dr M. Rucklidge; *Representatives of JAG*, Dr G.W. Hamlin (Chairman of JAG), Dr A. Nicholl (Secretary of JAG); *By invitation of the Chairman* Dr C. Verghese, Miss Jenny Firth-Cozens.

Association Linkmen

Names are grouped according to Regional Health Authority (Area in Scotland); the order of names within each group is arbitrary and without significance.

England

Northern (R.H.A. 1)

D.J.H. Daniel (*Hartlepool*); I.F. Riddle (*South Teeside*); R. Goodwin (*Durham*); D.C. Townsend (*South West Durham*); K.S. Cameron (*North West Durham*); C. Beeton (*Darlington*); I. Anderson (*Hexham*); D.J. Greaves (*Ashington*); M.R. Bryson (*Newcastle Central Section*); S.K. Greenwell (*North Tyneside*); S. Srivastava (*South Tyneside*); M. Marshall (*Newcastle Western Section*); P. Copeland (*Newcastle Eastern Section*); G. Harris (*North Tees*); R.M. Freeman (*Cumbria*); A.E. Brown (*Gosforth*); G. Earnshaw (*Barrow-in-Furness*).

Yorkshire (R.H.A. 2)

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The Committee on Enzymes of the Scandinavian Society for Clinical Chemistry and Clinical Physiology. Recommended method for the determination of gamma-glutamyltransferase in blood. *Scandinavian Journal of Clinical Laboratory Investigation* 1976; **36**: 119–25.
Anonymous. Epidemiology for primary health care. *International Journal of Epidemiology* 1976; **5**: 224–5.

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National Center for Health Statistics. Acute conditions: incidence and associated disability, United States, July 1968–June 1969. Rockville, MD: National Center for Health Statistics, 1972. (*Vital and health statistics, Series 10*: Data from the National Health Survey, No. 69) [DHEW publication No. (HSM) 72–1036].

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